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Air

⚡ EPA NETWORK DESIGN AND SITE EXPOSURE CRITERIA FOR SELECTED NONCRITERIA AIR POLLUTANTS

DISCLAIMER

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CONTENTS

FIGURES

TABLES

SECTION 1

INTRODUCTION

There is a need for air monitor siting guidelines that are applicable to the noncriteria air pollutants (NCAPs). The increasing need to consider the effects of known or suspected hazards has led Federal, State, and local air pollution control agencies to measure a variety of hazardous NCAPs. This has resulted in many short-term ambient air monitoring studies of NCAPs.

To increase the usefulness of NCAP studies, guidelines on network design and siting criteria are needed. Thus, the objective of this report is to provide monitor siting guidelines for selected NCAPs. A complete list of the pollutants treated in this document is given in Table 1. Most of these pollutants are toxic organic compounds that are priority substances for consideration as primary national health hazards. Seven of the listed pollutants have been identified as hazardous in compliance with Section 112 of the Clean Air Act (CAA).

Ambient monitoring data are needed to determine if the chemical is present in the ambient air and at what concentration, to assess population exposure estimates, and to determine the need for emission controls.

For many of the NCAPs, adequate methods to monitor still need to be developed. Thus, the monitoring activities will be undergoing improvements to the state-of-the-art methodologies initially put to use. The major objective of the monitoring activities is to apply available state-of-the-art techniques in data-gathering programs to observe air quality trends and to characterize noncriteria levels around critical sources and populations.

The monitoring siting criteria cover all NCAPs with the exception of pollutants associated with acid rain and visibility or as a criteria pollutant under Section 108 of CAA. Thus, pollutants such as sulfates, nitrates, inhalable particulates, and other "visibility" pollutants are excluded.

TABLE 1.   SELECTED NONCRITERIA POLLUTANTS
THAT NEED MONITOR SITING GUIDELINES

Acetaldehyde	Ethylene oxide
Acrolein	Formaldehyde
Acrylonitrile	Hexachlorocyclopentadiene
Allyl chloride	Maleic anhydride
*Arsenic	Manganese
*Asbestos	*Mercury
*Benzene	Methyl chloroform (1,1,1-trichloroethane)
Benzyl chloride	Methylene chloride (dichloromethane)
*Beryllium	Nickel
Cadmium	Nitrobenzene
Carbon tetrachloride	Nitrosomorpholine
Chlorobenzene	Perchloroethylene (tetrachloroethylene)
Chloroform	Phenol
Chloroprene	Phosgene
Chromium	Polychlorinated biphenyls
o-,m-,p-Cresol	Propylene oxide
p-Dichlorobenzene	*Radionuclides
Dimethylnitrosamine	Toluene
Dioxin	Trichloroethylene
Epichlorohydrin	*Vinyl chloride
Ethylene dichloride	Vinylidene chloride
	o-,m-,p-Xylene

* Listed as hazardous air pollutants under Section 112 of the Clean Air Act.

SECTION 2

MONITORING NEEDS FOR NONCRITERIA POLLUTANTS

MONITORING OBJECTIVES

It is important when planning air monitoring activities to clearly define the objectives to be met by the monitoring data. In general, the objectives of ambient monitoring are the following:

- Measure or characterize urban air quality

- Measure or assess specific source impacts.

If the NCAP data collected satisfy these two objectives, the monitoring program will satisfy all of the needs for ambient data.

DATA NEEDS

The data needed to meet the monitoring objectives will vary in accuracy, frequency of measurement, and spatial density, depending on the nature of the local situation, the nature of the hazard associated with the NCAPs, and the nature of the measurement process. With regard to the nature of the hazard for the 43 pollutants listed in Table 1, there are two classes of hazards, the 7 regulated pollutants already identified by EPA as hazardous substances, and the remaining 36 pollutants that are suspected to be hazardous and that are under consideration for regulation. However, ambient air quality levels that are accepted as hazardous have not been established for either class. Therefore, accuracy and frequency of measurement may be considered secondary to spatial variation. It will be most important to define what areas are affected by the pollutants. This is the data characteristic most closely tied to siting and network design that is the subject of this document.

The spatial variations of air quality levels may be defined by in situ monitoring at fixed sites, by mobile monitoring, by remote monitoring at fixed or mobile sites, or by some combination of the three. In situ monitoring may include in situ analysis or collection of samples by a media for subsequent laboratory analysis. The use of personal samplers to collect samples for laboratory analysis is another way of obtaining spatially variant data that are especially relevant to human exposure estimates. Although there are a number of ways of including spatial variability in the monitoring data, the use of fixed monitoring sites is most common and is the method for which quality control procedures are best established at present. In this document, primary emphasis is given to the use of fixed in situ monitoring sites.

The number of fixed monitoring sites needed to measure spatial variability of NCAPs for one or more monitoring objectives depends very much on the number, type, and magnitude of sources of emissions. Other influencing factors are the topography and meteorology of the local area. Methods of taking these factors into account in planning for the number and location of monitoring sites are described in Section 4.

PRINCIPAL USES OF DATA

Common uses of monitoring data listed in Table 2 were recently cited by the Ad-Hoc Work Group on Air Toxics Monitoring.* These data uses must be borne in mind when planning a monitoring network. There must be agreement between those who will use the data and those who will collect them regarding how many and what locations will meet the data needs. Sometimes this coordination is needed between groups within a single agency. However, more often there must be coordination between parties of different levels of Government or between Government and nongovernment parties. Some concepts regarding how data use relates to monitor siting are discussed below.

TABLE 2. COMMON USES OF MONITORING DATA
(cited by the Ad-Hoc Work Group on Air Toxics Monitoring)

- Determine air quality status and trends

- Develop and review air quality standards

- Determine source-receptor relationships

- Develop and evaluate emission control standards and strategies

- Initiate corrective action in emergency response

- Characterize urban air quality

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* November 1983, Second Draft. Long-Term Plan for Toxic Ambient Air Pollutant Monitoring (unpublished). The group consists of representatives from States, EPA Regions, Office of Research and Development, Office of Management Systems and Evaluation, and Office of Air Quality Planning and Standards.

Assess Human Exposure Risk

The relationship of measured ambient concentrations to human health or welfare risks depends on a number of factors regarding time and magnitude of exposure, which may affect how frequently samples are collected and analyzed. However, the most crucial concern from a siting point of view is often that the data represent or be related to the highest ambient concentration. This requires that the right location be sampled at the right time. Another consideration is the number and sensitivity of the exposed population. Children, elderly persons, and sick persons may be more susceptible to lower concentrations than are other people. Therefore, the concentrations to which highly susceptible people are exposed may be as important to health risk assessment as the magnitude and location of the maximum concentration. Site selections are often made to satisfy both needs, i.e., maximum concentration and concentration to which the maximum population or the most susceptible population is exposed.

Determine Air Quality Trends

Air quality trends are important to show whether pollution is getting worse or better and whether regulatory controls are adequate. The single most important siting consideration for trend data is that transient influences not representative of the region be excluded. The shutdown of a nearby plant or the shifts of traffic from a nearby highway are examples of transients that may be undesirable unless they represent the major effects in the region. Typical locations that are good locations for measuring trends are (1) the central business district of a large metropolitan area, (2) the edge of a metropolitan area downwind of the prevailing wind direction, and (3) a dense residential population area. Other types of locations may also be suitable, depending on what the local situation is regarding sources of emissions.

Develop and/or Validate Models

The use of models can greatly increase the amount of information developed regarding air quality levels over that given by a monitoring network. However, the model estimates are limited by the accuracy of the model. Monitoring data can be used to establish the validity of models and to provide a basis for improving models. This is particularly important where local terrain influences are present. The EPA guidance on validating models (e.g., U.S. EPA 1978) requires that monitoring be designed to describe the spatial variation of pollutant concentrations across the area. For each local situation the best selection of sites will depend on meteorology,

topography, and the configuration and characteristics of sources. The following examples are offered of four common types of local situations (U.S. EPA 1982); however, the adequacy of a network for a specific site may be expected to vary from these examples:

- For aerodynamic downwash, consider one or two background monitors plus two to four downwind monitors. The number of downwind monitors should be determined by a consideration of the frequency of the downwash events, the expected magnitude of the impact, and the areal extent of the impact.

- For shoreline conditions, consider one to two background monitors and three to eight downwind monitors. The number of downwind monitors should be determined by considering site characteristics, the magnitude and the areal extent of the predicted impact. It may be necessary to complement the stationary monitoring network with mobile sampling and plume tracking techniques.

- For complex terrain, the air quality monitors should assess the maximum impacts for each averaging period for which an air quality violation is expected to occur. Approximately three to eight monitors should be considered necessary to monitor for each such averaging time. The exact number depends on the magnitude and extent of expected violations. At least two monitors for each contiguous area where violations are expected to occur are necessary except where these areas are large. In this case, more than two monitors could be required. As a guide, a 22-1/2° sector should define the maximum size of a large contiguous area. Based upon meteorological judgment, additional monitors may be required to evaluate the source impact, depending on the complexity of the terrain.

- For urban situations where the concern is particulates and the sources of violations appear to be fugitive and/or reentrained dust, extensive monitoring and receptor models may be needed to accurately assess the problem.

Identify Areas of Effect or Exposure Levels

In order to estimate the area covered by a specific exposure effect, there must be a relatively large number of sampling sites. The number required will depend on the complexity of the local pattern of air quality levels. As a general rule it will be necessary to supplement monitoring data

with modeling estimates. It is desirable that the monitoring data be adequate
to identify the shape of the air quality pattern and the areas of sharpest
gradient. Remote sampling and mobile sampling can be useful adjuncts to
fixed-site monitoring in meeting this data use.

Determine Source Impact Areas

Much of what applies to defining integrated areas of effects over
a region can be applied to defining the impact area from a single source. A
number of monitoring sites are needed, and monitoring data can be usefully
supplemented by modeling data. The monitoring sites will be located in the
vicinity of the site, and will be most productive if they are sited in a
pattern that is downwind of the prevailing wind direction from the source.

Determine Pollutant Transport and Fate

Many air pollutants are relatively stable in the atmosphere. They
are transported out of the source area by the wind, being diluted by turbu-
lent mixing in the process. In most cases, pollutants remain airborne until
they are taken up by dry or wet particles and washed out by rainfall.
Some pollutants undergo rapid chemical transformations, which makes them
less toxic and often more susceptible to removal. In a few cases, pollutants
fall out because they are emitted as large particles that are not easily
retained as aerosols. Detailed chemical and physical analyses of pollutant
samples are useful in defining the fate of transported air pollutants.
Monitoring sites can be arranged in downwind lines at convenient distances
from major sources or source areas to obtain data that describe pollutant
transport fates.

SECTION 3

CHARACTERISTICS OF NONCRITERIA POLLUTANTS

PHYSICAL AND CHEMICAL PROPERTIES

In planning monitoring operations for NCAPs, it is useful to keep physical and chemical properties in mind. For this purpose, Table 3 identifies the 43 pollutants listed in Table 1 in terms of three properties that affect the emissions, transport, and fate of pollutants in the atmosphere. The three properties are volatility, reactivity, and physical state. Standard chemical references may be used to determine more details regarding these and other physical and chemical properties. A number of important characteristics of 26 compounds are listed in Appendix D to this report.

Volatility is related to the difficulty of containing a pollutant during production, handling, transport, storage, use, and disposition. Emission rates are likely to be higher for the more volatile compounds, and sources that use these materials are of concern from an air monitoring point of view. Reactivity relates to how fast the pollutant changes form in the atmosphere due to photochemical and other atmospheric chemical processes. Pollutants with higher reactivity will not travel far from their source before undergoing chemical transformation. The physical state of the compound may be of interest in selecting a sample collection technique. It may also be of interest in identifying handling and storage processes that are of concern as sources of emissions.

SOURCES OF EMISSIONS

An important step in selecting monitoring sites is identifying the nature and location of expected emissions of the pollutants of interest. A summary of emissions for the 43 pollutants identified in Table 1 is given in Table 4 for the following types of sources:

- Production plants

- Industrial user plants

- Sources that emit the pollutant as a byproduct or indirect emission

- Storage, transport, and fugitive sources.

In order to give an overview of the relative importance of these emissions, Table 5 is a ranked listing of total atmospheric emissions of 46 compounds (all from Table 1) in 1978. It may be noted that two of the pollutants in Table 1, namely nitrosomorpholine and dimethylnitrosamine are not commercially produced and not directly emitted to the atmosphere. These

TABLE 5. RANKED LISTING OF TOTAL EMISSIONS OF SELECTED NONCRITERIA AIR POLLUTANTS

Chemical	Total emissions* (lb/yr)
Toluene	2,235,842,590
Benzene	1,300,000,000
Methylchloroform	538,730,000
Perchloroethylene	500,000,000
m-Xylene	453,533,940
Methylene chloride	407,700,000
o-Xylene	268,497,360
Trichloroethylene	240,700,000
p-Xylene	239,270,414
Vinyl chloride	220,000,000
Acrylonitrile	190,000,000
Ethylene dichloride	180,000,000
Chlorobenzene	175,376,130
Carbon tetrachloride	65,030,000
p-Dichlorobenzene	49,900,950
Manganese	35,000,000
Formaldehyde	33,000,000
Chloroform	24,040,000

(continued)

* Actual emissions estimated as of 1978.

TABLE 5 (continued)

Chemical	Total emissions* (lb/yr)
Nickel	22,573,640
Chromium	15,000,000
Nitrobenzene	13,040,000
Asbestos	12,200,000
m-Cresol	10,960,000
Morpholinet	10,028,000
Arsenic	9,500,000
p-Cresol	9,124,941
Phenol	6,924,360
Cadmium	6,000,000
Acetaldehyde	4,853,950
Maleic anhydride	4,800,000
o-Cresol	4,504,150
Vinylidene chloride	4,300,000
Radionuclides	4,000,000
Chloroprene	3,523,092
Ethylene oxide	1,991,000
Mercury	1,900,000
Propylene oxide	1,346,160

(continued)

* Actual emissions estimated as of 1978.

† Precursor to atmospheric formation of nitrosomorpholine.

TABLE 5 (continued)

Chemical	Total emissions* (lb/yr)
Allyl chloride	1,110,000
Epichlorohydrin	479,000
Beryllium	357,035
Phosgene	253,176
Dimethylamine[†]	215,400
Acrolein	102,920
Benzyl chloride	100,271
Hexachlorocyclopentadiene	59,500
Polychlorinated biphenyls	30,020
2,3,7,8 TCDD (dioxin)	84

* Actual emissions estimated as of 1978.

† Precursor to atmospheric formation of dimethylnitrosamine.

compounds are primarily found in the atmosphere as a result of chemical reactions involving the precursors, morpholine and dimethylamine, respectively, which are listed in Table 5.

It may be noted from the description in Table 4 that the large quantities of emissions of the highest ranked pollutants in Table 5 are from many small, widely dispersed sources. Typical examples are the 1.3 billion pounds per year of toluene emitted from motor vehicle exhausts, the 579 million pounds per year of toluene emitted from paint and other coating solvents, and the 371 million pounds per year of methyl chloroform released from metal cleaning operations.

The sources of each pollutant have been characterized into the following four types:

- Well-isolated plant sites having major emissions

- . Industry-related sources that may or may not be well isolated from one another

- Sources identified with product use and related to popula-tion distribution

- Motor vehicle traffic.

Pollutants falling into each class are listed in Table 6. Some pollutants are listed in more than one class. These groupings will help in planning monitoring networks with respect to each pollutant. Further suggestions for using these classes to define monitor sites are presented in Section 4.

SAMPLING REQUIREMENTS

The sample collection for NCAPs differs from that of criteria pollutants, mainly in the fact that the sampling procedure is not specified as it is with criteria pollutants. Therefore, the analyst must evaluate the currently recommended and the most recently developed procedures to determine how the sample should be collected and analyzed. A list of sampling media and analysis methods for the pollutants addressed in this document is shown in Table 7. The problems encountered when specifying a sampling protocol are many; hence, a logical procedure that considers at least the following points should be followed:

- Media. Unless very expensive equipment is dedicated to field monitoring activities, samples will normally be collected as grab samples and brought to a laboratory for analysis. The media selected to collect each pollutant must have good collection efficiency for the compound(s) of interest, and it must retain and release the compound in

TABLE 6. CLASSES OF POLLUTANT SOURCES APPLICABLE TO
SELECTED NONCRITERIA AIR POLLUTANTS

I. Small number of well-isolated plant sites

Dimethylnitrosamine (vicinity of 13 plants emitting dimethylamine, rocket
  launches)
Allyl chloride (3 plants)
Epichlorohydrin (12 plants)
Acrolein (5 production and 3 user plants)
Ethylene oxide (13 plants)
Hexachlorocyclopentadiene (3 production plants)
PCBs (12 incinerator sites)
Phenol (16 production and 16 user plants)
Phosgene (18 production plants)
Propylene oxide (7 production and 30 user plants)
Acetaldehyde (5 production and 13 user plants)
Benzyl chloride (4 production and 15 user plants)
Chloroprene (3 plants)
Acrylonitrile (5 production and 25 user plants)
Ethylene dichloride (18 production plants)
Vinyl chloride (production and chemical specialty plants)
Maleic anhydride (7 production and many specialty user plants)

II. Emissions related to specific industries and many users

Formaldehyde (wood products, chemical specialties)
Manganese (ferro and silico alloys, power plants, iron and steel plants,
  foundries)
Nickel (power plant oil combustion)
Nitrobenzene (cellulose ether and petroleum plants)
Beryllium (power plant coal consumption)
Cresols (wire coating plants, coke ovens, mining sites)
Radionuclides (power plant coal consumption)
Chromium (refineries, steel plants, cement plants)
Mercury (power plant coal combustion, incinerators, mercury and zinc
  refineries)
Cadmium (iron and steel plants, copper and zinc smelters)
Asbestos (production plants, building demolitions)
Arsenic (copper smelters, glass plants, refining plants)
Benzene (petrochemical plants, coke ovens, gasoline refineries)
Vinylidene chloride (chemical specialty plants)

(continued)

24

TABLE 6 (continued)

III. Emissions related to population density

Dioxin (use of wood preservatives, incinerators)
Formaldehyde (wood products in homes)
Methyl chloroform (degreasing)
Methylene chloride (paint remover, degreasing)
Nitrosomorpholine (vicinity of morpholine emissions, mainly boiler
    corrosion inhibitors, and polishes and waxes)
Nickel (oil combustion, including diesel)
Toluene (paints and adhesives)
Trichloroethylene (degreasing and cleaning)
Xylenes (adhesives, household products, pesticides)
Carbon tetrachloride (miscellaneous household and commercial products)
Chlorobenzene (cold cleaners, pesticides)
Chloroform (solvent in pharmaceuticals and pesticides)
Cresols (disinfectant/cleaning compounds)
p-Dichlorobenzene (space deodorant, moth control)
Perchloroethylene (dry cleaning, metal cleaning)
Arsenic (coal combustion, pesticide use)
Asbestos (building demolition)

IV. Emissions related to motor vehicle use

Toluene
Xylene
Benzene
Asbestos

TABLE 7. SUGGESTED ANALYSIS METHODS FOR APPLICABLE SAMPLING MEDIA

Organic pollutant	Sample collection media*				
	Tenax-GC	Charcoal	Impinger	PUF**	Other
Acetaldehyde			1		2 (Bubbler reagent)
Acrolein			1		
Acrylonitrile					3 (Canister, mole sieve)
Allyl chloride					3 (Canister, cryogenic)
Benzene	3				
Benzyl chloride	4,5				4,5 (Canister)
Carbon tetrachloride	4,5				4,5 (Canister)
Chlorobenzene	4,5				4,5 (Canister)
Chloroform	5,6				
Chloroprene	4,5				
o-,m-,p-Cresol	4,5		4,5	4,5	
p-Dichlorobenzene	4,6				6 (Cryogenic)
Dimethylnitrosamine	7				7 (Thermosorb-N)
Dioxin					4 (Submicron filter)
Epichlorohydrin	4,5				4,5 (Cryogenic)
Ethylene dichloride					4,5 (Cryogenic)
Ethylene oxide		4,5			4 (Canister)
Formaldehyde			1		2 (Bubbler reagent)
Hexachlorocyclopentadiene	4,5			4,5	6 (Porapak T)
Maleic anhydride					None available
Methyl chloroform	4,5				4,5,6 (Canister)
Methylene chloride					4 (Canister, mole sieve)
Nitrobenzene	4,5				4,5 (Canister)

(continued)

* Analysis method:
   1. Spectrophotometric
   2. Derivitization, high performance liquid chromatograph
   3. Gas chromatograph/flame ionization detector
   4. Gas chromatograph/photoionization detector
   5. Gas chromatograph/mass spectrometry
   6. Gas chromatograph/electron capture detector
   7. Gas chromatograph/thermal emission analyzer
   8. High performance liquid chromatograph

** Polyurethane foam.

TABLE 7 (continued)

Organic pollutant	Sample collection media*				
	Tenax-GC	Charcoal	Impinger	PUF**	Other
Nitrosomorpholine					8 (Thermosorb-N)
Perchloroethylene	4,5				4,5 (Canister)
Phenol	4,5		5		
Phosgene					Field analysis only, due to instability of compound
PCBs				5,6	6 (Florosil)
Propylene oxide	4,5				4,5 (Cryogenic)
Toluene	4,5				4,5 (Cryogenic)
Trichloroethylene	6				6 (Cryogenic)
Vinyl chloride	4,5				4,5 (Cryogenic)
Vinylidene chloride	4,6				4,6 (Cryogenic)
o-,m-,p-Xylene	4				

Inorganic pollutant	Sample media	
	Hi-vol filter	Other
Arsenic	1	
Beryllium	1	
Cadmium	1	
Chromium	1	
Manganese	1	
Nickel	1	
Asbestos		Microscopy (millipore filter)
Radionuclides		α, β, and γ spectroscopy (millipore filter)
Mercury		Atomic absorption spectrometry (silver wool)

* Analysis method:
 1. Spectrophotometric
 2. Derivitization, high performance liquid chromatograph
 3. Gas chromatograph/flame ionization detector
 4. Gas chromatograph/photoionization detector
 5. Gas chromatograph/mass spectrometry
 6. Gas chromatograph/electron capture detector
 7. Gas chromatograph/thermal emission analyzer
 8. High performance liquid chromatograph

** Polyurethane foam.

a predictable and reliable way. Cost of the media, sample preparation, and extraction are all necessary considerations when designing a sampling program.

● Procedure. The procedures listed in Table 7 primarily use collection on solid media--either filters, Tenax-GC, or charcoal. Most of the information was extracted from the EPA "Technical Assistance Document for Sampling and Analysis of Toxic Organic Compounds in Ambient Air" (Riggin 1983). A more complete description of the sampling and analytical methods is provided in Appendix A of this document. Table 7 shows columns headed with the various collection media used for organic compounds. Suggested analytical methods for each compound are indicated by numbers that are identified in a footnote. A procedure for each phase of the sampling program must be written out in advance of the sampling activity in order to anticipate how each step is to be done. Phases of the sampling activity include preparation, field sampling, and sample analyses. Procedures must be written to describe media preparation, e.g., preconditioning, assembly (if necessary), sample handling, and analytical procedures to be followed. In addition to sample preparation and handling, a plan is needed for how much air must be sampled to obtain the amount of pollutant necessary to meet the minimum detectable limits of the analytical procedure. The volume of air necessary to sample can be determined by estimating the concentration of the pollutant in the ambient air and calculating what volume of air would contain the amount of pollutant necessary to meet the minimum detectable quantity attributed to the analytic procedure. A margin of safety should be added for less than 100 percent capture efficiency of the media. Consideration must be given to the possi- bility of collecting too much of a compound in a single sample tube, i.e., so that some of the material in the sample passes through. Considerable study has been directed to the breakthrough volume of Tenax. Breakthrough volume for a variety of volatile organic compounds has been reported by Krost et al. (1982). Estimated detection limits are also given for most of the compounds listed by Krost.

Determination of the volume of air to sample can be shown using the following simple example. Assume that the detection limit for a compound is 15 ng per ml and the compound is extracted into 5 ml of solvent. The sample would need to contain 75 ng of the pollutant in order to be detectable. Assume the concentration of the pollutant in the atmosphere typically ranges from 5 to 25 ng/m^3. The volume of air to be sampled would range from 3 m^3 in areas of high concentration to 15 m^3 in areas where low concentrations exist. If the sample media were only 80 percent effective in capturing the pollutant, the volume of air to be sampled would be increased by 25 percent. Unfortunately, the capture efficiencies of sampling media are not readily available for many of the compounds of interest. It may be necessary to assume collection efficiencies much lower than 80 percent.

AIRBORNE TOXICITY

Table 8 presents recent information on the toxicity of the 43 pollutants listed in Table 1. The reason for providing these data is to assist monitoring planners in setting priorities for selecting monitoring sites oriented to certain pollutants. Sites that measure pollutants for which toxic effects are dubious or for which the expected ambient concentration is low relative to toxic levels, can be assigned a low priority. When funds limit the number of sites that can be set up and the number of samples that can be collected and analyzed, these data may be helpful.

The toxicity effects of greatest concern relate to severe body cell irregularities, including carcinogencity and mutagenicity. For 13 of these compounds, other toxic effects are of concern. Seven of the listed compounds, including arsenic, asbestos, benzene, chromium, nickel, radionuclides, and vinyl chloride, are known carcinogens. Two of these, radionuclides and vinyl chloride, are also mutagens. For all of the others, the evidence on carcinogenicity and mutagenicity varies from completely unknown to probable but uncertain. Two of the compounds, acrolein and phosgene, are known to be not carcinogenic but to have other toxic effects.

SECTION 4

SITING PROCEDURES

To assist in selecting monitoring sites, specific procedures have been developed for different scales of air quality representativeness. A description follows of what scales of representativeness may occur, how to identify what scales of representativeness are applicable to a specific area of monitoring responsibility, and some recommended guidelines for locating monitors for each scale.

REPRESENTATIVE TYPES OF MONITORING SITES

Spatial Scales of Representative Air Quality Levels

Because the air quality measured at a single site is based on a sample of air from a very small volume, it is useful to know over how large an area this value can be considered representative. The concept of representative spatial scale is used to designate this area. The spatial scale of representativeness means the physical dimensions of the area within which a monitoring station is located that pollutant concentrations are reasonably similar.* The following five scales are defined in Appendix D of Part 58, Title 40 of the Code of Federal Regulations:

- Microscale--defines the concentrations in air volumes associated with area dimensions ranging from several meters up to about 100 m.

- Middle Scale--defines the concentration typical of areas up to several city blocks in size with dimensions ranging from about 100 m to 0.5 km.

- Neighborhood Scale--defines concentrations within some extended areas of the city that have relatively uniform land use with dimensions in the range of 0.5 to 4.0 km.

- Urban Scale--defines the overall citywide conditions with dimensions on the order of 4 to 50 km. This scale would usually require more than one site for definition.

- Regional Scale--defines usually a rural area of reasonably homogeneous geography and extends from tens to hundreds of kilometers.

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* Similar means extreme concentrations are within 25% of the mean for the area. If larger values occur, the area would need to be subdivided until this similarity criterion is met.

Relevant Representative Spatial Scales

As described above, the spatial scales of representativeness depend on the spatial variability of air quality levels. Observable physical properties that primarily determine air quality levels are the sources, air movements, and atmospheric transformation and depletion processes. In Section 3, there are data and methods to characterize data that may be used to estimate these determinants of air quality. Experience suggests that a good emission inventory is the most useful single factor in estimating air quality levels. Additional needed information includes a climatological summary of the combined influences of wind direction, wind speed, and atmospheric stability and an estimate of rapid removal processes (e.g., coarse particulate matter settles out of the air quickly, and highly reactive chemicals transform to other substances quickly).

In each monitoring area, the locations and emission rates of sources for each pollutant of concern need to be identified as well as possible. Table 4 may provide some help in identifying sources, and Table 6 suggests prototypes of source configurations that are most likely to be associated with the 43 pollutants with which this report is primarily concerned. It would be convenient to link source configurations to representative air quality configurations. However, this requires that the meteorology of different areas of the country be relatively consistent. A review of annual surface wind roses in the Climatic Atlas of the United States (U.S. Department of Commerce 1968) shows this is not the case because patterns of wind direction are highly variable across the country. The next best alternative is to devise a methodology for selecting monitoring sites that takes the local air quality pattern into account. A methodology has been developed for representative spatial scales. The air quality pattern will be related to the source pattern. The scale of interest with respect to a source pattern will depend on the monitoring objectives and may vary from determining the maximum effect to determining the maximum area within which a measurable impact can be detected. Table 9 suggests the range of representative scales that are of interest with respect to each of four types of source configurations. Because, for the pollutants of interest in this study, we are generally concerned with ground-level sources, there will always be a microscale area of maximum air quality level near or within the source configuration of primary concern. The extent to which larger scale air quality effects are also of interest will vary with the monitoring objectives.

OVERVIEW OF SITING PROCEDURES

A general method for selecting sampling sites is outlined in Figure 1. This procedure is applicable to all the representative spatial scales. The The monitoring agency must be able to present a strong argument that the data collected represent the real concentration pattern or exposure potential. Sampling locations will be selected to fulfill the monitoring agency's information needs, such as maximum concentration, frequency distribution of the typical concentrations, spatial variations of the concentration,

TABLE 9. REPRESENTATIVE SCALES APPLICABLE TO
TYPES OF POLLUTANT SOURCES

Type of source	Representative scales
Isolated plant	Micro to neighborhood
Small area	Micro to neighborhood
Large area	Micro to urban
Traffic	Micro to urban

```
┌─────────────────────────────────────┐
│       Determine source types         │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│   Determine if seasonal variations   │
│     occur with pollutant sources     │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│   Select upwind or downwind sectors  │
│      from climatological summary     │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│      Determine areas impacted by     │
│    sources using dispersion model    │
│          approach (optional)         │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│    Determine optimum distances for   │
│   sampling under various conditions  │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│    Prioritize the candidate sample   │
│   sites with respect to information  │
│       from modeling and wind data    │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│      Select actual sampling sites    │
│    by visiting candidate areas and   │
│    imposing the basic site criteria  │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│      Prioritize the sites for final  │
│              selection               │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│    Perform screening sampling, if    │
│               desired                │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│          Final site selection        │
└─────────────────────────────────────┘
```
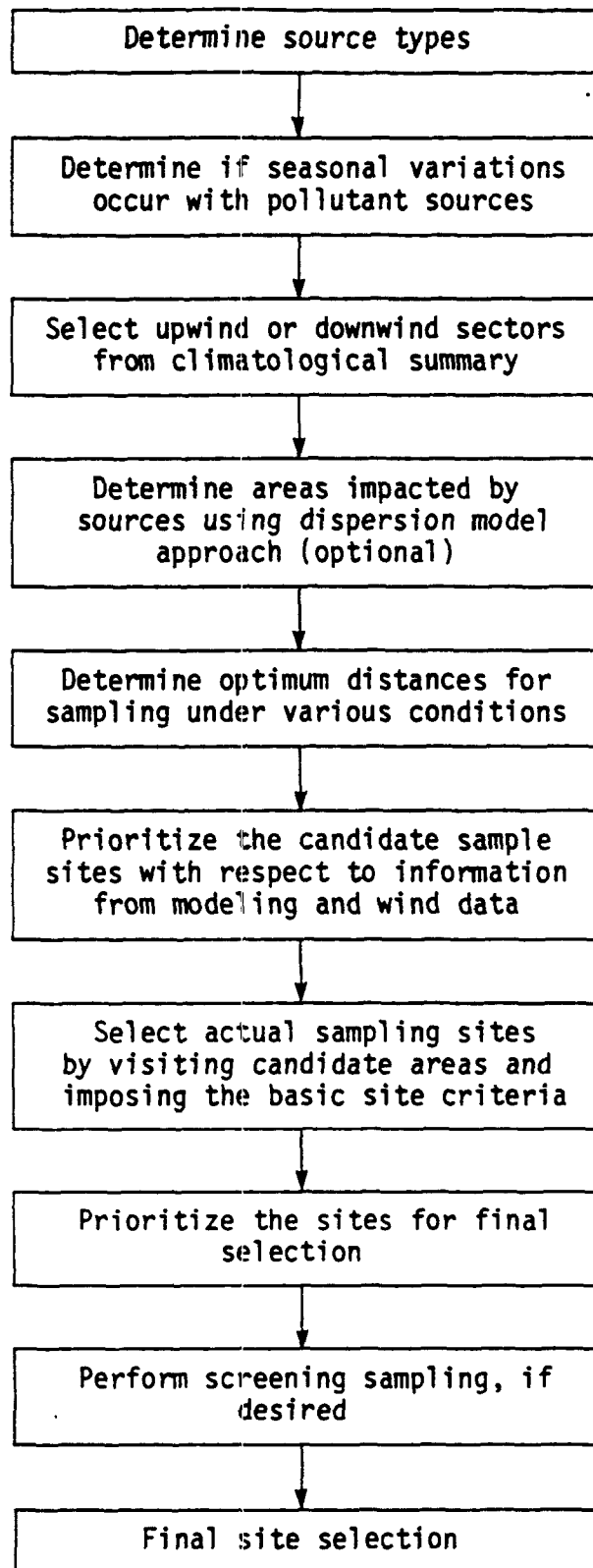
Figure 1.   Site selection procedure.

etc. The objectives of the sampling activity must be clearly stated so the sampling strategy and locations can be selected to collect the most relevant information.

The first step in the site selection procedure is to determine sources. The logic that this step requires is depicted in Figure 2. The type of sources that will be encountered and their locations are combined with meteorological information in the next step of the procedure. A representative climatological wind summary is needed. A wind rose (see Figure 3) readily shows the prevalent wind directions and most frequent wind speed. From the wind data, the logical sectors for downwind (impact) or upwind (background) sites can be determined.

Dispersion modeling is a good way to analyze the available source and meteorological data in an objective manner to identify areas of relatively good and poor air quality. Model results may be used to define distances from sources to find maximum concentrations or the most frequently impacted areas, which is the next step in the procedure. Site selection can be narrowed down to zones within the sectors favored by wind direction and to zones within those sectors that will be impacted by emissions as indicated by modeling. A preliminary prioritization of candidate sites can be made based on the modeling information. However, the candidate areas should be viewed before final evaluation. A semifinal ranking of all locations can be finalized after preliminary or screening sampling has been performed.

The site selection procedure described above is appropriate to all sources in a general way but is most appropriate to sources that may be defined as point sources or small area sources. Depending on the spatial scale of the monitoring problem, an area source can be considered as a point source if the monitoring location is far enough downwind (e.g., on the order of 5 to 10 times the diameter of the area source). Monitoring area sources may require sampling sites along the perimeter of a well-defined small area source or sampling within the perimeter of a large area source.

The following criteria are recommended guidelines in the final site selection step:

- Locate the sampler in an area that has unobstructed air flow, especially in the direction of any recognized sources of the materials being sampled. Turbulence and eddys from obstructions will cause nonrepresentative results. The distance between the obstruction and the sampler should not be closer than two times the height of the obstruction.

38

```
┌─────────────────────────────┐
│  Identify monitoring area   │
│  and pollutants of concern  │
└─────────────────────────────┘
              │
              ▼
┌─────────────────────────────┐
│ Determine source types within│
│  and near monitoring area   │
└─────────────────────────────┘
              │
              ▼
┌──────────────────────────────────────────────────────┐
│  Pollutant use and/or generation     Source type      │
│                                                        │
│    Captive--used as              Isolated plant        │
│     intermediate                                       │
│                                                        │
│    Large volume chemical         Isolated plant or     │
│     used by few industries       small area            │
│                                                        │
│    Large volume chemical         Area (small or        │
│     used by many industries      large)                │
│                                                        │
│    Large volume chemical         Large area            │
│     used by industry and/or                            │
│     public                                             │
│                                                        │
│    Combustion product            Point or traffic      │
└──────────────────────────────────────────────────────┘
```
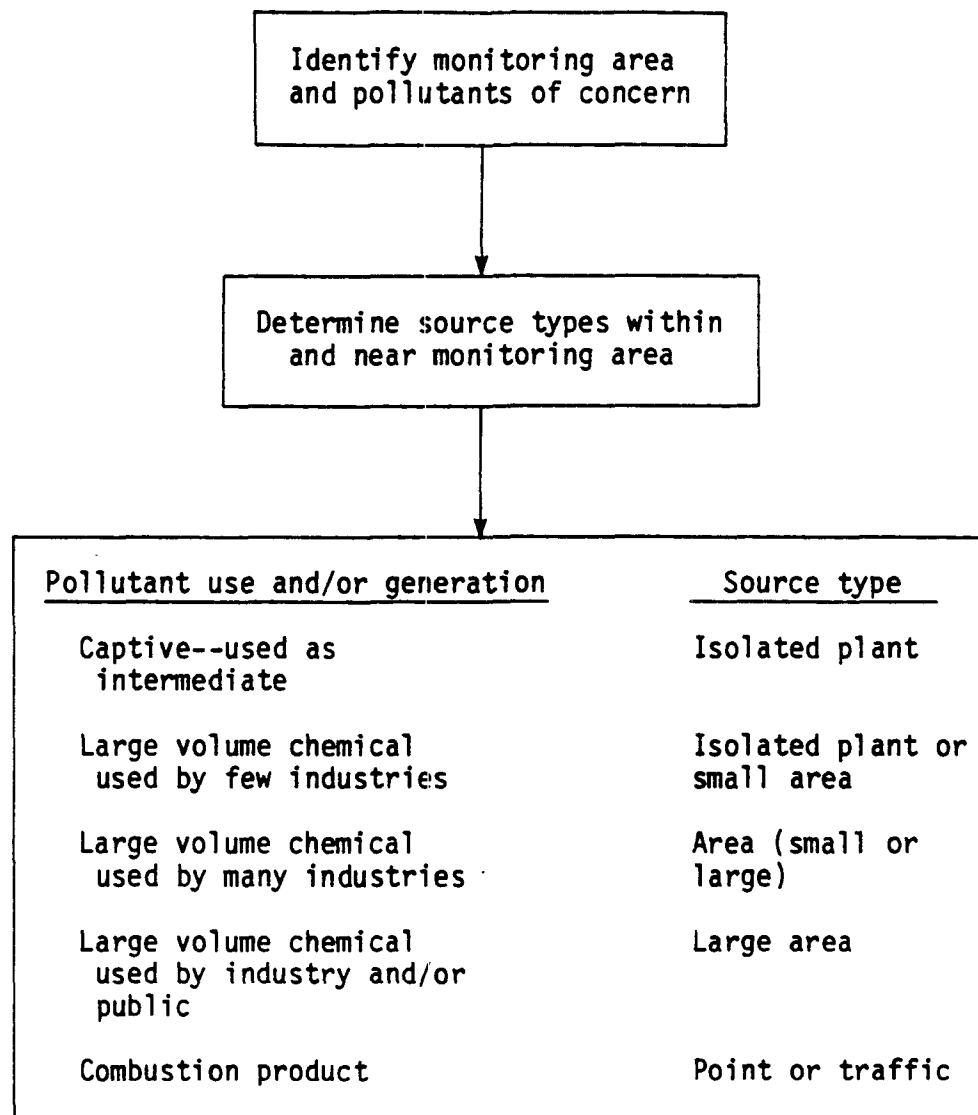
Figure 2. Source configuration.

● Avoid locations that will be unduly influenced by nearby
   sources or activities.

● Avoid locations where reactive surfaces may cause chemical
   changes in the air sampled.

● Be aware of micrometeorological influences due to nearby
   hills, bodies of water, valley drainage flow patterns,
   etc.

● Place the intake probe at a representative height. The
   guidance given for criteria pollutants is for probe height
   to be 3 to 15 m above ground level, as near to building
   height as possible but not where a building is an obstruc-
   tion or the equipment is easily vandalized.

● The probe should extend at least 2 m from a supporting
   structure; if located on a building, it must be mounted on
   the windward side.

   Monitoring site selection criteria should be the same in most regards
whether the site will be used for a fixed station or for the nonfixed
(mobile) site. Uniformity among the sites should be achieved to the greatest
degree possible. Descriptions should be prepared for all sampling sites.
The description, at a minimum, should include the type of ground surface;
the direction, distance, and approximate height to any obstruction to airflow;
and the direction and distance to any local pollutant sources (actual or
potential). Photographs of the site are valuable for analysts who will not
have firsthand knowledge of the site.

Monitoring Point and Isolated Area Sources

   Once an isolated source of interest is identified, the preferred
sampling locations are selected based on climatological data and perhaps
dispersion modeling information. Representative wind data for an isolated
area is especially important for plants that are built in a coastal area.
Many of the chemical plants that are of concern for noncriteria air pollutants
are built along the Gulf Coast where sea-breeze effects will be an important
factor in sample site selection. An experienced meteorologist's advice will
be necessary to interpret available data and to select the most suitable
locations for downwind sampling. Accessibility to the desired locations may
be a determining factor for final site selection; therefore, site visits will
be necessary in order to ensure that monitoring is practical in the selected
area.

For stack emissions, the sites should be selected to indicate the locations of ground impacts of the maximum concentrations. For area sources normally at or near ground level and that have no buoyancy, the maximum concentration will occur within a few meters of the downwind boundary of the source; therefore, sampling sites should be along the perimeter of the area source. If elevated point sources are combined with ground-level releases in the source configuration, dispersion modeling is recommended to indicate where the combined impact will cause the maximum concentration. A number of samples will be necessary in order to be confident that the small plume from a small source will impact the sampler. The dimensions of the area source will dictate how many samplers will be necessary to represent the maximum pollutant concentration. Judgment based on experience and knowledge of the character of the source will provide guidance on the number of samplers to place. If the source is not well characterized, more samples must be obtained. Also, if only one or a few isolated sources are present, the likelihood of the source impacting each sampling site is small; hence, more samplers are required. For pollutants that are very reactive, the downwind distance from the source should be kept to a minimum to avoid degradation of the pollutant due to chemical reactions.

Monitoring Large Area Sources

Characterizing the air quality resulting from a large number of small sources will be less difficult due to a higher probability of finding the areas of maximum impact. As with all site selection activities, the first steps are to characterize the sources of the pollutant as best as it can be done, and identify areas with the highest likelihood of maximum impact using climatological wind data and dispersion modeling. Special attention is needed to select sites that offer the most potential for adverse impact, e.g., maximum concentration or maximum population exposure. One problem is evaluating the frequency and magnitude of the pollutant emissions. The source with the highest emission rate and the greatest potential for adverse impact is a good starting point. Locations that have the potential to be affected by multiple sources, i.e., locations on the downwind edge of a large source area, are important. Which of these two types of locations will experience higher maximum concentrations or more frequent exposure to the pollutants may depend on the duration of the exposure time that is of concern.

Monitoring Irregular and Widespread Small Emissions

Pollutants used in small quantities by the general public or industries will require long-term sampling programs at locations where exposure may be a matter of special concern. Characterizing the exposure potential requires knowledge of when and where the pollutant will be generated or emitted so that a minimum of unnecessary sampling is done. The best judgment must be made of where and when to sample at sites that conform to good siting criteria with respect to the expected sources. With the probability of the pollutant occuring in a low concentration, the sites selected should avoid areas where high concentrations of other compounds may interfere with the analysis of the pollutant specifically being sought.

Pollutants that are frequently used in small quantities by industry and the public will be nearly ubiquitous. Site selection will depend upon the resources available to carry out the sampling program. Sampling sites should be placed in as many locations as necessary to describe the population exposure. Sampling sites selected should be within populated areas and afford the most representative site that can be obtained over a neighborhood or urban scale area.

SITING PROCEDURES FOR REPRESENTATIVE SPATIAL SCALES

In the preceding section, it was recommended that spatial scales of interest to a specific area of concern be defined by considering types of source configurations and monitoring objectives. Procedures for selecting monitoring sites are presented for the following scales of sites:

- Urban scale

- Neighborhood scale

- Microscale or middle scale.

Urban Scale Sites

A methodology for selecting sites that represent urban scale air-quality levels is presented in Figure 4. In general the method consists of identifying the largest area with which effects of interest may occur, eliminating areas that are not representative of urban scale effects, and emphasizing areas that are representative of high concentrations over widespread areas.

The first step is to assemble data. Seven specific types of data that will be useful are listed in Figure 4. Because urban scale effects are of interest, emissions are possible over a large area and from many sources. The locations and emission rates of sources need to be identified. If a local compilation is not available and cannot be made, information from the following sources may be helpful:

- EPA data bases (e.g., NEDS and NESHAPS)

- State emission inventory

- New source registration/application files

- Table 4 of this report

- EPA reports (e.g., Suta 1979).

```
┌─────────────────────────────────────────────┐
│ Assemble data on                            │
│ ● Sources (location and emissions)          │
│ ● Population density                        │
│ ● Sensitive population facilities           │
│ ● Low elevation terrain                     │
│ ● Wind roses                                │
│ ● Stable-atmosphere wind rose               │
│ ● Obstacles to wind flow                    │
└─────────────────────────────────────────────┘
                      │
                      ▼
┌─────────────────────────────────────────────┐
│      Identify the area that includes most   │
│               small sources                 │
└─────────────────────────────────────────────┘
                      │
                      ▼
┌─────────────────────────────────────────────┐
│   Delete areas subject to small-scale       │
│   influences of major point and highway     │
│                 sources                     │
└─────────────────────────────────────────────┘
                      │
                      ▼
┌─────────────────────────────────────────────┐
│     Delete areas with low population        │
│                densities                    │
└─────────────────────────────────────────────┘
                      │
                      ▼
┌─────────────────────────────────────────────┐
│      Identify remaining areas with the      │
│   following good siting characteristics:    │
│   ● Near sensitive population facility      │
│   ● In prevailing downwind sector           │
│   ● In low elevation terrain                │
│   ● In prevailing stable-atmosphere         │
│     downwind sector                         │
│   ● Open (free of wind obstacles)           │
└─────────────────────────────────────────────┘
                      │
                      ▼
┌─────────────────────────────────────────────┐
│   Select sites with as many good siting     │
│       characteristics as possible           │
└─────────────────────────────────────────────┘
```
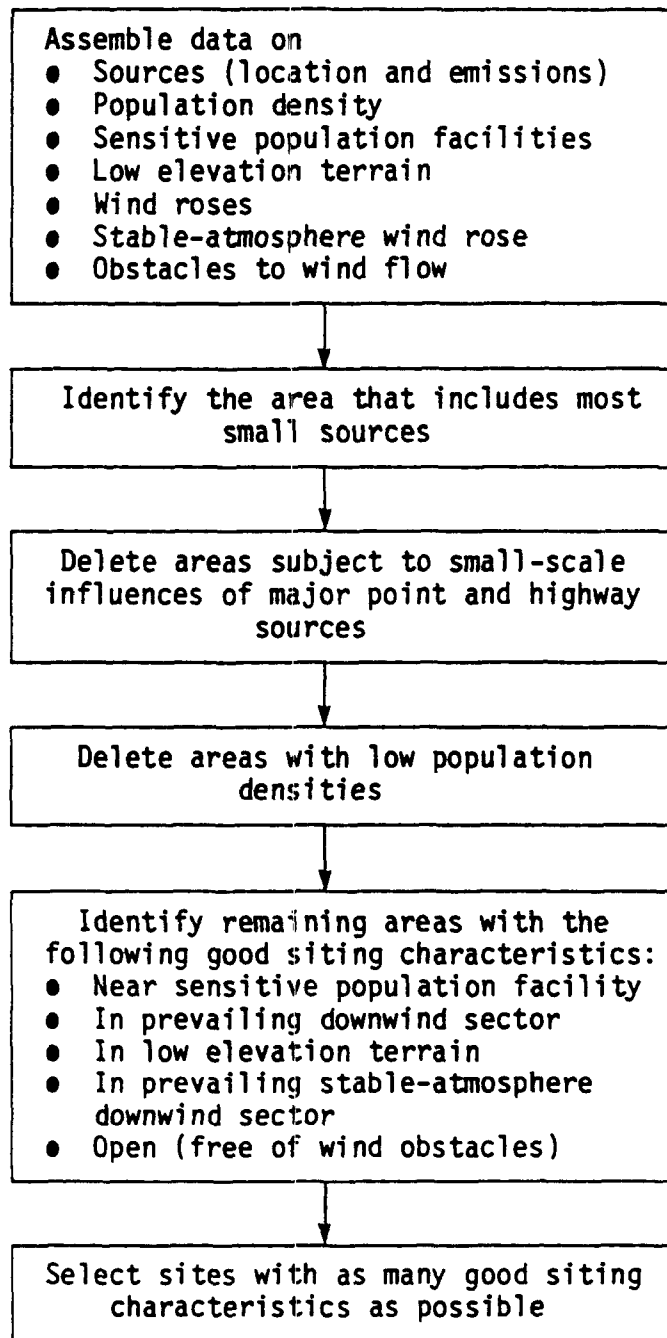
Figure 4. Steps for locating an urban scale site.

Data on population density can be determined from land-use maps available from local urban planning agencies, zoning commissions, and similar types of organizations. U.S. Census data of population densities in small sub-tracts will also be helpful, but it does not reflect the daytime population distribution. The locations of sensitive population facilities (e.g., hospitals, nursing homes, day care centers, elementary schools) can be located using telephone yellow pages if they are not identified on local maps.

Topographical maps are valuable for showing the locations of low-lying and elevated terrain. The information assembled can be conveniently summarized using either topographical (e.g., U.S. Geological Survey maps) or land-use maps.

Information on wind flow is best obtained from wind roses (i.e., a graphical display showing the frequency of occurrence of wind directions). If possible, wind roses for the occurrence of stable atmospheric conditions and light wind speeds should be obtained in addition to a local annual wind rose for surface winds. These are available from the National Climatic Data Center (NCDC) in Asheville, North Carolina, or they may be compiled from an available source of local wind observations. Before wind data not obtained from a National Weather Service (NWS) station is used, a meteorologist should be consulted to determine whether the measured winds are representative of pollution transport over the urban scale area. In fact, a meteorologist should be consulted on the representativeness of any wind data for the scale or location of interest.

Because buildings, trees, and prominent terrain can obstruct air flow, the locations of such air flow obstructions need to be noted in selecting monitoring sites. Aerial photographs and visual inspections of areas to be monitored are usually adequate to identify unsuitable sites.

After data relevant to characterizing the air quality pattern is assembled, an analysis can be made of representative and nonrepresentative monitoring locations. A characteristic of the sources when an urban scale effect is representative is many small sources over a large area. If there are one or more predominantly large sources, there may not be a well-defined urban scale effect. In this case, neighborhood and small-scale siting are more appropriate.

The area surrounding most of the small sources that make up the large source area should be delineated as the first step of the analysis. If this area is less than about 5 km in diameter, urban scale air-quality levels will occur outside the source area. Otherwise, an appropriate urban scale monitoring site should be sought within the source area.

Additional steps should be taken to identify locations that have either desirable or undesirable representation characteristics. Locations close to major sources (e.g., high-traffic roadway or relevant processing

plants) are to be avoided. Locations in deserted areas and areas that are entered infrequently day or night do not demonstrate population exposure hazards and are to be avoided. Desirable location characteristics include high population density (day and/or night); sensitive populations (e.g., hospitals, child day care centers, retirement homes, etc.); susceptible to air pollution episodes (e.g., low lying; downwind of the source area during stable, light wind conditions); and free of prominent building and terrain influences.

A useful guide to selecting desirable sites is to mark areas for each desirable and undesirable characteristic on a map that also shows the source area. Areas that have the most desirable siting characteristics and no undesirable characteristics can be easily designated. These areas can be further reviewed by visual inspection and by mobile or temporary monitoring.

The following guidelines are offered to help identify desirable and undesirable monitoring areas:

Ground-Level Stationary Source Influence--
There are no absolute rules as to how far away the emissions from a stationary source are significant. One limitation is the detection-sensing threshold of available monitoring techniques. Another limitation is the horizontal gradient of concentrations, because once the gradient approaches the gradient of ambient concentrations, the effects of the source are no longer detectable. Through the use of optimum sample collection media and analytical instruments, detection-sensing thresholds need not be a limitation. Recommended monitoring techniques for many of the NCAPs of interest are given in Appendix A. As an example, a detection threshold of 5 ng/m^3 means that a source strength of 0.1 mg/sec (about one third of an ounce per day, or less than 10 g, per day) is detectable within a 130-m wide swath at a distance of 1 km from the source (i.e., assuming neutral stability and a 2 m/sec wind speed blowing from the source toward the sampler for an hour). The variations in ambient concentrations that can be expected in urban areas are shown by the data collected by Singh et al. (1982). For convenient reference, these observations are presented in Appendix B. For toluene, hour-to-hour variations are shown to be as great as 20 $\mu g/m^3$. For most other pollutants, the hour-to-hour variations are more typically 2 $\mu g/m^3$ or less. Table 10 shows maximum distances from sources that a contribution can be measured for given ratios of the source contribution to the source strength. In many cases the ratio of ambient variations to source strength will not be known, but 10^{-4} may be a reasonable expectation. Based on the results in Table 10, locations within 1.3 km of such stationary sources will not represent urban scale air quality during the night. The data in Table 10 suggest that the distance to which a source can have a significant impact on ambient concentrations is highly variable and can be quite large. The data in Table 11 may be used to help estimate ambient concentration variations and source strengths that need to be considered for many of the pollutants of concern. By inspection of the data shown in Appendix B, it appears 10 to 20 percent of the mean of the

TABLE 10. MAXIMUM DISTANCE FOR SELECTED RATIOS OF MONITORED
CONCENTRATION TO SOURCE STRENGTH

Ratio of monitored concentration to source strength (s/m^3)	Distance (km) for stability class*		
	C	D	E
10^{-3}	0.14	0.2	0.3
$3x10^{-4}$	0.3	0.4	0.7
10^{-4}	0.5	0.8	1.3
$3x10^{-5}$	0.9	1.8	2.8
10^{-5}	1.7	3.7	6.1

* Assumes wind speed of 2 m/s. Based on data in Workbook of Atmospheric Dispersion Estimates (Turner 1970).

TABLE 11. AMBIENT CONCENTRATIONS AND EMISSION FACTORS

Pollutant	Observed urban concentrations* (ng/m^3)	Typical emission factors[†]
Benzene	4800-15000	0.13 g/mi from motor vehicles[§]
Methylene chloride	1400-6300	1.8 lb/yr per person
Chloroform	0-730	Production 0.11%; solvent use 100% (7% of product)
Carbon tetrachloride	820-1700	Production 0.22%; solvent use 100% (8% of product)
Methyl chloroform	1500-5500	100.0% most degreasing and solvent uses
Vinylidene chloride	11-30	Unknown
Trichloroethylene	250-1800	87 lb/day from open top vapor degreasing operations
Perchloroethylene	1100-4800	1.6 lb/yr per person for dry cleaning, 12 lb/day from vapor degreasing operations
Chlorobenzene	510-4100	0.32% production, 0.04 g/s at cold cleaning operations
p-Dichlorobenzene	0-1600	0.72% production, 0.22 lb/yr per person
Formaldehyde	0-3300	0.48% of usage
Phosgene	120-130	0.018% production
Acrolein	9200-21000	0.11% production
Nitrobenzene	0-460	2.8% of cellulose production, 1 lb/10^3 bbl crude oil capacity
Dimethylnitrosamine	25-28	0.2% of dimethylamine production
Toluene	17000-57000	0.38 g/mi from motor vehicles, 3.7 lb/yr per person from solvents
o-Xylene	2800-10000	0.6 lb/yr per person from solvents, 0.035 g/mi from motor vehicles
m-,p-Xylene	6100-23000	1.6 lb/yr per person from solvents, 0.074 g/mi from motor vehicles
Phenols	120-120	0.22% production

* 25th and 75th percentiles of compiled observations (Brodzinsky 1982).
† From EPA, OAQPS compilation entitled "Human Exposures to Atmospheric Concentrations of Selected Chemicals" (Systems Applications, Inc., 1980).
§ Assumes benzene is one-third of toluene emission rate (Bucon, Macko, and Toback 1

observed range is a reasonable estimate of expected hour-to-hour variations in ambient concentrations. Data observed at urban locations for each of the pollutants listed in Table 11 are also available (e.g., see Brodzinsky et al. 1982).

Mobile Source Influence--
Mobile source emissions are by nature less concentrated than stationary source emissions, because they are spread over a line rather than emitted from a single point. As a result, the concentrations of pollutants from mobile sources are lower and decrease less rapidly with distance. Both these effects result in a more homogeneous effect on urban scale air quality at distances closer to highways than to stationary sources. Figure 5 shows how concentrations vary downwind of a typical high-traffic urban highway. The values shown are representative effects of toluene emissions from automobiles, as computed by the EPA HIWAY2 model. These results suggest that 150 m from the highway, the gradient of concentrations from the highway emissions has become nearly flat and thus spatially homogeneous. As a further guideline, the concentration with travel distance from a line source was examined for a range of typical meteorological conditions. The ratio of the minimum concentration of interest to the estimated highway emission rate was used to determine how far from the highway an urban scale monitor must be located. In most cases, 0.5 km from the most dense traffic roads will be an adequate distance for an urban scale site.

Population Density--
Data from the most recent U.S. Census can be used to identify high density residential areas. Land-use and zoning maps prepared by metropolitan planning commissions are good sources of nonresidential, high-population access areas and remote areas with very low population access. The types and forms of census data available for a specific area can be determined by contacting the Bureau of the Census (Data User Service Division, Customer Services (Publications), Washington, D.C. 20233).

Sensitive Population Facilities--
Sensitive population facilities can be located by consulting common references such as local directories and public service organizations. The number of people accommodated and the hours of operation may also be of interest, as well as location of each facility, because this additional information is easily acquired.

Prevailing Downwind Sector--
Next to an emission inventory, a climatological summary of wind directions is the most useful information for selecting monitoring sites. The frequency of occurrence of wind direction on an annual basis or for any specific time period or special condition (e.g., by atmospheric stability

class) can be tabulated from hourly observations or obtained from the National Climatic Data Center for National Weather Service observing stations. The stability data from NCDC are particularly convenient for this purpose. Table 12 shows an example of the type of data that can be requested. In this example, the relative frequency of occurrence of 16 wind direction classes are given for six wind speed classes and Pasquill class D stability (i.e., as defined by Turner 1964 for standard NWS observations). For NWS data observations collected since 1964, the wind direction can be tabulated by 10° intervals instead of 16 compass point classes. If air quality observations are based on samples collected for 24 hours, a more useful tabulation of wind data is the frequency of occurrence of classes of 24-hour resultant wind directions (see Figure 6). It is a good idea to limit the resultant wind tabulation to days that the wind direction is reasonably persistent as defined by a wind persistence indicator, calculated by taking the ratio of the resultant to the 24-hour arithmetic mean wind speed. In Figure 6 the data are limited to days with a wind persistence indicator of 0.85 or greater.

A tabulation in the format of Table 12, including all stabilities, is recommended to identify the prevailing downwind direction for 1-hour sampling periods. Figure 7 illustrates how the prevailing wind direction and the identified source area may be combined to define the prevailing downwind sector of the source area. The first step is to determine by visual inspection the longest trajectory line across the source area that is parallel to the prevailing wind. In this example, 75 percent of this distance is chosen as a high-exposure distance. All locations that have an upwind trajectory of at least this length are identified as the high-exposure areas.

Prevailing Stable Light Downwind Sector--
The preceding discussion places emphasis on finding a frequently exposed monitoring site. Another area of concern is that exposed to the highest concentrations regardless of frequency. For ground-level sources, this will be periods of low wind speed and a stable atmosphere. Under these conditions, the pollutant remains in the vicinity of its source or slowly drifts with the circulation created by the thermodynamic influence of the city on the otherwise stagnant air. The prevailing wind direction during a stable atmosphere (Pasquill classes E and F) and light wind speeds (i.e., less than 2 m/s) can be determined using a data tabulation such as the one shown in Table 12 for E and F stability combined. It is interesting to note that, for the distribution in Table 12 under the column for the totals of all wind speeds, northwest is the prevailing wind direction. However, for the 0 to 3 knot wind speed column, southeast is the prevailing wind direction.

51

The procedure illustrated in Figure 7 may be repeated for the prevailing direction under stable light wind conditions. However, if there is a high frequency of reported calm winds, it is recommended that the downwind section be extended to include the center of the source area.

In identifying the prevailing wind direction during light wind conditions, it is important that the meteorological observations be representative of the source area. If the source area is on one side of a large metropolitan area, wind observations from an airport on the opposite side may be misleading. If representative wind data are not available, it would be best to consider the center of the source as the primary exposure area for stagnant air situations. Low-lying terrain is also subject to high pollution during stagnant meteorological conditions.

Low Terrain Areas--
Just as the organization of building structures can influence the flow of air that is stagnant, so can the shape of the terrain. This can be a problem at night when air close to the ground cools rapidly. Cooler air is more dense and will readily displace warmer air at a lower elevation. This leads to nocturnal drainage flows and embedded drainage plumes. As a result, the low point in a source area or the side of a source area to which the air drains will be an area of relatively high nighttime air pollution. These areas can be best identified by examining a topographical map that shows low lying areas and the locations to which air overlying the source area can be expected to drain.

Open Areas--
Locations that are shielded from the general ambient flow by steep bluffs, by buildings, or by trees are poor sampling locations because they frequently are representative of a very small local area that is cleaner or dirtier than a more open area. Open areas that are free of obstructions can best be identified from land-use maps and from visual inspection of the general area to be monitored.

Neighborhood Scale Sites

A methodology for selecting neighborhood scale monitoring sites is shown in Figure 8. Situations in which neighborhood scale air quality effects are of interest occur for an urban area within or around which there are well-defined sources that consist of either small areas of many industrial or commercial operations or large integrated plant sites. The methodology consists of characterizing significant variations in the air quality pattern and the density of population exposed to air quality. Areas of poor, medium, and good air quality and the nature of the overall population exposure threat can be identified by monitoring a range of different neighborhoods. The methodology provides a systematic way of assembling and evaluating information in order to plan a useful monitoring network.

55

The first step in the analysis is to assemble data on sources, population, wind, and terrain. Relevant data were cited in the preceding discussion of urban scale sites.

The second step recommended in Figure 8 is to map the population density and to identify the locations of sensitive population facilities. U.S. Census sub-tract data for urban areas, land-use maps from urban planning agencies, and land-use statistics (e.g., floor space, number of employees, business volume) from tax collection and other relevant agencies are sources of data for defining the population density. It is recommended that the available data be used to divide the monitoring area into high, medium, and low population areas for both day and nighttime periods. For most uses of monitoring data, this is an adequate spatial distinction. Of all the available data, Census data are the most easily related to spatial distribution. It is recommended that population densities based on Census data best represent the nighttime population distribution. Areas of high residential population density should be modified for daytime distribution estimates to include locations with high employment and major shopping centers. It is a relatively simple matter to plot the available data on residential population densities on a map and to divide the monitoring area into zones of low, medium, and high population density. The zones can be modified on a second map to include areas of high employment and major shopping when these activities lie outside the high population zone. These zones should be used as a guide in selecting neighborhoods to include in the complete monitoring network.

The locations of sensitive population facilities should also be noted on a map. Suggestions for identifying and locating sensitive population facilities are given in the preceding section.

The next step is to determine the expected spatial distribution of air quality levels. One way to characterize air quality levels over the monitoring areas of concern is to perform an air quality simulation using one of the standard mathematical models. If one is reasonably confident about the location and emission rates of the sources, if representative meteorological data are available for the area, and if the area is free of major terrain complexities, computer modeling will provide a convenient and comprehensive analysis of the distribution of air quality levels over the area of interest. Models recommended for different source configurations and different averaging periods are shown in Table 13. It should be noted that when multiple pollutants are being considered, a separate model run is needed for each pollutant with different sources or with a different distribution of emissions from the sources. Results from a single simulation are applicable to all pollutants that have the same sources and that have emission rates among the sources that are equal or proportional. For guidance on the use of models and the preparation of input data, consult the Guideline on Air Quality Models (U.S. EPA 1978) and the Regional Workshop on Air Quality Modeling--A Summary Report (U.S. EPA 1982).

TABLE 13. RECOMMENDED EPA MODELS BY SOURCE CONFIGURATION AND AVERAGING TIME*

Monitoring station	Averaging time	
	Annual mean	Maximum 1 to 24 hour
General urban area		
- area and point sources	CDM	RAM
- with complex sources	ISC	ISC
Urban area with single or multiple major source(s)	CDM	RAM
Single source with terrain height below stack top[†] (complex source)	CRSTER	CRSTER (ISC)
Single source near terrain above stack top[§]	COMPLEX I or VALLEY	VALLEY or COMPLEX I

* Available in EPA UNAMAP System (Version 5).

† For multiple sources where it is not appropriate to consider the emissions as located at a single point, the MPTER model is appropriate.

§ COMPLEX I and VALLEY are considered screening techniques. For regulatory purposes, COMPLEX I should be used only with onsite meteorological data as input.

These models treat inert pollutants but provide useful approximations for reactive pollutants also. Application of models for reactive pollutants is a special study requiring a specialist in chemically reactive models, more sophisticated computer modeling, and special input data preparation. This level of detail is not usually required for siting studies.

A large metropolitan area may be characterized by well over 1000 different neighborhoods. Although mathematical modeling is the most satisfactory way to classify the air quality potential of neighborhoods, it is also possible to classify neighborhoods in a more qualitative fashion by examining the locations and magnitudes of sources in relation to wind direction frequencies and topographical influences. This approach amounts to using the data needed in a modeling study in a more qualitative manner. Estimates of emissions must be prepared for all areas of the city. One method is to divide the city into homogeneous subareas, each about the size of a neighborhood (i.e., 0.5 to 4 km in diameter). A land-use map prepared by local zoning or urban planning agencies may be suitable for this purpose. If a suitable land-use map is not available, one may be prepared by interpreting aerial photographs and other available sources of information. Table 14 suggests a land-use classification scheme (after Auer 1978) that may be used to guide the preparation of a land-use map. Of course, any large point source of each pollutant of concern should be analyzed separately. The data presented in Section 3 may help to identify which neighborhoods emit which pollutants, and provide a basis for determining an emission rate. However, for many NCAPs, new and better information on sources and emission rates is being assembled as part of EPA's continuing review of potentially hazardous pollutants. Regional offices should be consulted for references to the most current information on each pollutant of interest. An extensive compilation of emission rates and sources of emissions for most of the NCAPs listed in Table 1 was published in a recent EPA study of human exposure estimates (Systems Applications, Inc., 1980 and Suta 1979).

The frequency of occurrence of wind directions must also be determined. These data are available from the National Climatic Data Center for all metropolitan areas. It is necessary to identify only the location that is most representative of the areas to be monitored. Appendix C contains a list of readily available data summaries.

The locations of major topographical features must also be identified relative to the source areas. The following topographical features are of interest:

- Central business district boundary

- Urban development boundary

- Undeveloped area boundaries (including parks, wooded areas, open areas, etc.)

- Major bodies of water

- Terrain elevation contours.

The number of neighborhood scale monitoring sites to be selected will depend on the monitoring objectives, the number of pollutants of concern, and the resources available. However, neighborhoods can be categorized as high, low, or medium with respect to concentrations of each pollutant, by using the information described above. The following guidelines are recommended:

1. High concentration neighborhoods

   ● Neighborhoods with highest emission density, i.e., mass emitted per unit area

   ● Neighborhoods downwind of prevailing wind from the area with highest emission density, particularly one with a relatively high emission density

   ● Neighborhood at the downwind end of the longest trajectory over areas with significant emissions.

2. Low concentration neighborhoods

   ● Neighborhoods with lowest emission density

   ● Prevailing upwind side of areas with significant emissions.

3. Medium concentration neighborhoods

   ● Between high and low concentration neighborhoods

   ● Adjacent to high concentration neighborhoods

   ● Neighborhoods with sensitive population, high population density, or major projected growth.

In determining prevailing downwind and upwind directions, the available data on wind direction frequencies should be modified to account for the influence of topographical features. A meteorologist should be consulted on how to estimate topographical influences.

A specific site within a selected neighborhood should be free of the influence of individual sources, or the measurements will not represent the neighborhood scale. Figure 9 provides an aid in determining how far away a ground-level point source can influence a monitor. Elevated stacks would have significantly less influence. To use the graph, an estimate is made of the general or area source emissions from a square kilometer in the vicinity of potential monitoring sites. The plotted lines in Figure 9 show the distance beyond which a point source will contribute less than 10 percent of the ambient concentration due to nearby area sources that

extend 2 km upwind of the receptor, as a percentage of the area source emission density. Plotted lines are presented for three Pasquill stability classes in order to show how variable the estimates could be in a 1-hour steady wind condition. It is recommended that the D stability graph be used as a guide in determining how far to locate monitors from a nearby point source. It may be seen that large sources will influence monitors 6 km or more away. If it is necessary to locate a monitor closer than the suggested impact distance from a point source, it is recommended that a site be selected in a direction from the source that has a low frequency of occurrence, as shown from wind direction data.

Microscale or Middle Scale Sites

When measuring air quality concentrations that represent the microscale or the middle scale, one is generally dealing with the influence of specific nearby sources, such as a large plant or a highway. There are two points that are of concern: (1) the point of maximum impact due to contributions from the source alone and (2) the point of worst air-quality level due to the combined impact of the source and contributions from all other sources. In selecting these points, there are a number of factors related to the nature of the source, the meteorology, and the topography of the area that need to be taken into account. Figure 10 presents a systematic, step-by-step procedure for selecting monitoring sites.

The first step is to assemble relevant data on sources, meteorology, and terrain. The following data are recommended:

- Source

    - Emission, including annual and maximum hourly rates and diurnal variations
    - Effective height of source plume, including rise due to heat and momentum of exhaust gas
    - Areal extent of source emission area
    - Source owner's property boundaries.

- Meteorology

    - Frequency statistics for joint occurrence of wind direction and atmospheric stability classes
    - Wind direction frequencies.

- Terrain

    - Topographical map showing terrain elevations, water bodies, developed areas.

63

The maximum impact of ground-level emissions occurs close to the source. Site selection considerations for monitoring the influence of elevated sources, usually well marked by stacks, are more complex. Ground level emissions will be associated with either a plant site or a highway. To monitor the maximum impact of a ground-level source, it is necessary to get as close to the source as possible and still be in a zone of concern because of the exposure hazard to the public. The major factor to take into account is the wind direction. However, only periods in which emissions occur and during which the emissions are least diluted due to atmospheric turbulence need to be considered.

When considering NCAP emissions from point sources, until exposure time standards are set, it may be necessary to consider both long-term and short-term mean concentrations. The meteorology of the area may be such that the maximum long-term and short-term impacts occur at different locations. An air quality simulation model may be used to identify the locations of maximum impact. The impacts can be assessed using the CRSTER or the ISC models. (See the preceding discussion for recommendations and references regarding the use of these models.) As a quick alternative to modeling, one can use routine meteorological data summaries to select sites. The following guidelines are recommended for selecting the location of the maximum short-term impact:

1. Determine most stable atmospheric class associated with periods of high emissions. If emission rate has no diurnal variations, select most stable class (Pasquill class F for rural areas, class E for urban areas).

2. Determine wind direction with greatest frequency of occurrence for selected stability.

3. Select location close to source fence line and downwind of source in direction of most frequent wind transport for selected stability.

For the location of maximum long-term impact, the following guidelines are recommended:

1. Determine the climatologically prevailing wind direction (highest frequency of occurrence annually). Day and night-time summaries are available and should be used for sources that have primarily day or nighttime emissions.

2. Select location close to source fence line and downwind of source in direction of prevailing wind.

When considering NCAP emissions from highways, it is desirable to account for possible correlations between diurnal variations in emissions and wind direction. If two sampling sites can be allocated to the source, one could place a site on either side of the area of maximum traffic flow. If only one site is to be used, it is important that the site be on the side that is downwind of the highway most frequently during periods of maximum traffic. If peak traffic occurs from 7:00 a.m. to 8:00 a.m. and from 5:00 p.m. to 6:00 p.m., the frequency of wind directions during very stable and very unstable conditions should be excluded. It is recommended that the most frequent wind direction for Pasquill stability classes C, D, and E be used to determine on which side of the highway to locate a monitoring site. The monitoring site should be located as close to the highway as is practical for monitoring gaseous pollutants or pollutants collected using size selective intakes. If standard hi-vols are to be used, the siting guidelines for distance from roadways given in 40 CFR 58 for TSP monitoring, should be followed.

For elevated sources, the distance to the zone of maximum impact and the effect of meteorological conditions on its location must be taken in account in selecting a site for monitoring the maximum impact of the source. The use of air quality simulation models, such as CRSTER and ISC, is the recommended way of determining the locations of maximum short-term and long-term contributions to ambient concentrations. These models will take the effect of variations in wind speed and atmospheric stability into account in estimating the degree of plume rise, as well as the direction of travel and dilution of the plume by turbulence. The models provide a comprehensive analysis of the effects of hourly variations in meteorological conditions of the patterns of air-quality effects. This provides the best estimate of where the maximum short-term and long-term concentrations will occur. An alternative is to take the following short-cut steps using the graphs in Figures 11 and 12 to select the location of maximum short-term concentration:

1. Use "Procedure for Evaluating Air Quality Impact of New Sources" (U.S. EPA 1977, pp. 4-7 to 4-9) or other equivalent procedures to estimate effective source height for each stability class with significant emissions.

2. Use Figure 11 or 12 to determine stability condition and downwind distance that give maximum concentration.

3. Use climatological data to determine wind direction with greatest frequency of occurrence for selected stability condition.

4. Select site in the downwind direction of most frequent wind for selected stability, at distance of maximum concentration (Step 2).

The following steps are an alternative for selecting a long-term monitoring site, if modeling cannot be performed:

1. Determine effective source height for neutral stability using the EPA guidelines (U.S. EPA 1977).

2. Use Figure 11 or 12 to determine the distance to the maximum impact for neutral stability (class D).

3. Select a site in the downwind direction of the prevailing wind (all stabilities combined) at the distance of maximum neutral stability impact.

The monitoring locations selected by the above procedures should be reviewed and possibly revised by taking topographical effects into account. This is particularly true in areas of complex terrain and where the meteorological data were not observed in the vicinity of the source. However, a meteorologist should be consulted before making any significant change in site selections. The following topographical influences should be considered:

● Complex terrain results in air flow being channeled by valleys, drained near steep terrain slopes, and modified by mountain-valley circulation effects.

● Large water bodies induce air to flow toward land during the day and toward water at night.

● Urban developments induce air to flow toward city centers.

Finally, in selecting specific probe locations in the vicinity of a selected monitoring location, the guidelines presented in the preceding section should be followed.

SECTION 5

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APPENDIX A

RECOMMENDED MONITORING TECHNIQUES

This appendix consists of Tables 17 and 18 extracted from EPA Technical
Assistance Document (TAD) (EPA-600/4-83-027). Table A-1 lists the most
widely used sampling and analysis methods for ambient air monitoring. A
discussion of the methods (also taken from the TAD) describes a logical
grouping of compounds that can be analyzed by the suggested methods.
Table A-2 is a list of 31 toxic organic air pollutants and the recommended
sampling and analytical methods from Table A-1.

Methods A-F (Table A-1) represent sampling and analysis approaches
for volatile hydrocarbons and halogenated hydrocarbons with boiling points
less than 200° C. The simplest approach (Method A) involves direct injection
of a gas sample onto a GC/FID or other detection system and is useful for
compounds more volatile than benzene. Higher boiling compounds can be
determined in some cases, although condensation onto the container surface is
a more significant problem as volatility decreases. Use of sensitive and/or
selective detectors such as ECD for halocarbons and PID for aromatics (19) or
certain olefins can be of great value.

Method B involves cryogenic concentration of a whole air sample.
Preferably this approach is used as a field method so as to avoid sample
transport and storage problems, although laboratory analysis has been used
successfully (5). This approach is more time consuming but also much more
sensitive than the direct GC injection approach and can be used at the part
per trillion level in favorable cases (e.g., using GC/ECD or PID). Compounds
in the C_2-C_{10} volatility range can be determined using cryogenic trapping.
A limited volume of air (<500 ml) can be sampled since condensed moisture
will plug the trap if greater air volumes are collected.

Methods C and D involve the sampling of ~20 liters of air using Tenax (a
porous polymer adsorbent), thermal desorption of the adsorbed components, and
GC or GC/MS analysis. Method C is more comonly used and involves direct
desorption of the Tenax-adsorbed components onto the GC or GC/MS system.
Method D involves desorption of the components into an evacuated canister and
subsequent analysis of the canister contents. Method D offers the advantage
of replicate analysis of a single sample, but is somewhat less sensitive than
the former approach. Adsorptive losses of higher boiling compounds onto the
canister surface is another potential problem. An advantage of the Tenax
approach, relative to cryogenic trapping, is that water and other inorganic
atmospheric components are not retained. Storage of the organic components
in the resin-adsorbed state also tends to circumvent problems with adsorption
on container surfaces.

Major disadvantages of the Tenax adsorption approach is the potential for artifact formation (e.g., by interaction of ozone with the resin) and/or contamination. These factors tend to increase the background (blank) levels relative to cryogenic trapping, thereby adversely affecting the detection limit. The widely varying retention volumes for organic compounds on Tenax requires careful consideration for each monitoring situation. A recent report describes the Tenax adsorption process and gives retention volume data for many organic compounds of interest (25).

Methods E and F involve adsorption of volatile, nonpolar compounds on carbon based adsorbents followed by solvent extraction or thermal desorption and GC or GC/MS analysis. Method E, adsorption of charcoal followed by extraction with CS_2 or other solvents, is the basis for many of the NIOSH methods. Unfortunately this approach is not sufficiently sensitive for most ambient air monitoring programs, although the use of selective detectors can improve sensitivity for certain compounds.

Method F has been used to some extent for ambient air monitoring of vinyl chloride and other volatile compounds. This method is similar to Method D, except that carbon molecular sieves are used in place of Tenax. Direct thermal desorption/GC analysis (analogous to Method C) could be employed for carbon molecular sieves as well. A major advantage of this approach is the strong retention of vinyl chloride and other highly volatile materials. However, the high temperatures required for thermal desorption from carbon based adsorbents can lead to degradation of strongly adsorbed, nonvolatile and/or polar materials.

Methods G, H, and I represent approaches useful for the determination of semivolatile or nonvolatile compounds (i.e., boiling points greater than 140° C). Method G, while referenced as a PAH analysis method, is readily adapted for the determination of many nonvolatile materials adsorbed on atmospheric particulate material. Method I is referenced as a separate method for tetrachloro-dibenzodioxins (TCDDs) which are currently of great environmental concern. Highly specific cleanup and GC/MS steps are used to gain selectivity for TCDDs using the method.

Method H represents as useful approach for PCBs, PCNs, organo-chlorine pesticides and other semivolatile compounds which can occur in both the particle and vapor state. Such compounds are not retained using conventional high volume filtration techniques hence adsorbents such as XAD-2 or poly-urethane foam (PUF) must be used in back of the filtration device. The semivolatile components are then recovered from the adsorbent by solvent extraction. Tenax is less useful than XAD-2 or PUFs in this method since many solvents will partially dissolve Tenax.

The remaining methods in Table A-1 represent specialized techniques for selected groups of compounds. Methods J and K are used for determination of volatile aldehydes (C_1 to C_6). Method J involves formation of the DNPH derivatives of the various aldehydes followed by reversed phase HPLC analysis, whereas Method K captures the aldehydes as bisulfite addition products and then employs a variety of colorimetric and GC analytical procedures for the individual aldehydes. Method J should generally be used if a wide variety of aldehydes are to be determined or if interferences with the colorimetric methods are likely to be encountered. The determination of formaldehyde using chromatropic acid, as in Method J, is a simple procedure and is very useful for screening purposes, although negative and positive interferences can occur.

Detection of alcohols in ambient air has not been of widespread interest and no sensitive methods exist. Method L refers to a group of NIOSH methods employing carbon adsorption and solvent desorption/GC analysis. These methods are not useful below 100 ppm. Alcohols are not retained on porous polymer adsorbents such as Tenax and are likely to decompose if carbon adsorption/thermal desorption approaches are attempted. An analytical method involving silylation of alcohols followed by cryogenic trapping of the silylated derivative (as in Method B) has been reported (23).

Nitrosamines are of considerable environmental significance because of the toxicological hazard and potential for formation in various combustion sources. Method M refers to an approach involving collection of the nitrosamine on a specially treated nylon adsorbent (thermosorb/N) and subsequent analysis using GC with MS or thermal energy (TEA) detectors. The latter detector is relatively specific for nitrosamines (16). Since both MS and TEA are relatively expensive detectors, the less expensive GC/NPD approach may preferable in relatively "clean" environments in which ultimate selectivity is not necessary. Thermosorb/N minimizes the formation of nitrosamines on solid adsorbents during sampling, which has proven to be a problem on Tenax under certain sampling conditions.

Methods N-Q represent the best available methods for determining aliphatic and aromatic amines. Nitrogen heterocycles containing no other polar functional groups can usually be determined by one or more of the methods described earlier for hydrocarbons, using nitrogen selective detectors. Methods N and P represent NIOSH procedures for determining aliphatic and aromatic amines, respectively. These methods involve adsorption of the compounds on silica gel, elution with acid and GC/FID analysis. The adsorption of water reduces the capacity of the silica gel and limits the practical sampling volume. Therefore, these methods cannot determine low ppb levels of amines, although use of GC/NPD should increase the sensitivity somewhat. HPLC with fluorescence, electrochemical, or UV detection (13) can improve the detection limit for aromatic amines.

Method O involves determination of volatile aliphatic amines (C_1-C_4) by adsorption on alkali-treated silica (Porasil A) followed by thermal desorption and GC/NPD analysis. This method is reported to achieve 1-5 ppb sensitivity if the GC system is carefully conditioned (11). Method Q is a similar approach using Tenax/thermal desorption for aromatic amines. However, the thermal instability of many aromatic amines must be considered and may limit the usefulness of this approach.

Relatively few analytical methods are available for determining acidic compounds (with the exception of phenols) in ambient air. Phenol itself and possibly cresols can be determined using a Tenax adsorption approach such as Method D. Higher boiling phenols can be determined using a resin adsorption/ solvent extraction approach such as Method H. Method S represents a standard method for phenols wherein the compounds are collected in a dilute sodium hydroxide impinger and then steam distilled and analyzed by GC/FID or GC/MS. Less volatile phenols can be analyzed (without steam distillation) by HPLC with fluorescence, UV or electrochemical detection.

Volatile carboxylic acids such as a formic and acetic acid can be determined (Method R) by collection in a dilute sodium carbonate impinger followed by ion chromatographic (IC) analysis (10). IC is a special form of ion exchange HPLC wherein conductance detection is employed (mobile phase buffer is removed prior to detection using a stripper column).

Suitable methods for determining sulfonic acids in air have not been reported. However, collection in an aqueous impinger followed by HPLC analysis (14) appears to be a viable approach.

In order to provide the reader with some useful examples of appropriate methodology, Table A-2 lists a group of toxic organic compounds of concern in ambient air monitoring programs. The most appropriate methods for determining these compounds, specific literature references, and additional analytical considerations are presented in Table A-2. This information should be used as guidance and will not be accurate for every monitoring situation.

The majority of the compounds in Table A-2 represent hydrocarbons, volatile halogenated hydrocarbons, or semivolatile halogenated hydrocarbons which can be determined using conventional cryogenic trapping, Tenax adsorption/ thermal desorption, or resin adsorption/solvent extraction approaches. A few compounds (e.g., acrylonitrile, allyl chloride, ethylene oxide) are too volatile to be captured on Tenax and require use of carbon adsorbents or cryogenic trapping. Several of the compounds can be determined using the procedures for aldehydes (e.g., formaldehyde, acetaldehyde, acrolein).

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APPENDIX B

OBSERVATION OF DIURNAL VARIATIONS OF
SELECTED NONCRITERIA AIR POLLUTANTS

Data are presented for the following NCAP:*

Figure	Pollutant
B-1	Benzene
B-2	Carbon tetrachloride
B-3	Chlorobenzene
B-4	Chloroform
B-5	Methyl chloroform
B-6	Methylene chloride
B-7	Perchloroethylene
B-8	Toluene
B-9	Tricholorethylene
B-10	m-,p-Xylene

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* Reported by: Singh, H.B., L.J. Salas, R.E. Stiles, and H. Shigeishi.
  1982. Measurements of Hazardous Organic Chemicals in the Ambient Atmosphere.
  SRI International, Menlo Park, CA.

APPENDIX C

METEOROLOGICAL DATA TABULATIONS AVAILABLE
FROM THE NATIONAL CLIMATIC DATA CENTER

Cities for which Stability Array (STAR) data tabulations are available are listed alphabetically by date and by city within a state.* Additional tabulations may be available since this compilation. For assistance on orders contact:

Director
National Climatic Data Center
Federal Building
Asheville, North Carolina 28801

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* From: Changery, M.J., W.J. Hodge, and J.V. Ramsdell. 1977. Index--
  Summarized Wind Data. BNWL-2220 WIND-11 UC-60, U.S. Department of Commerce,
  National Climatic Data Center, Asheville, NC.

C.-1. EXPLANATION OF ENTRIES

CITY is the city or town name for the location at which the original observations were taken. It may also be the name of a military installation.

NAME-TYPE is usually the airport or field name and/or service which operated the station. If these had changed during the period summarized, the name and/or service valid for the longest portion of the summary is used. A few stations may have no identifying information.

Under NAME, commonly used abbreviations are:

APT	-	Airport
ATL	-	Air Terminal
BD	-	Building
CAP	-	County Airport
CO	-	County
FLD	-	Field
GEN	-	General
GTR	-	Greater
INL	-	International
MAP	-	Municipal Airport
MEM	-	Memorial
METRO-		Metropolitan
MN	-	Municipal
RGL	-	Regional
TERM	-	Terminal

Under TYPE, commonly used abbreviations are:

AAB	-	Army Air Base
AAF	-	Army Air Field
AAFB	-	Auxiliary Air Force Base
AEPG	-	Army Energy Proving Ground
AF	-	Air Force
AFB	-	Air Force Base
AFS	-	Air Force Station
ANGB	-	Air National Guard Base
ASC	-	Army Signal Corp
CAA	-	Civil Aeronautics Administration
FAA	-	Federal Aviation Administration
FSS	-	Flight Service Station
LAWR	-	Limited Airways Weather Reporting (Station)
MCAF	-	Marine Corps Air Facility
MCAS	-	Marine Corps Air Station
NAAF	-	Naval Auxiliary Air Facility
NAAS	-	Naval Auxiliary Air Station
NAF	-	Naval Air Facility
NAS	-	Naval Air Station
NAU	-	Naval Air Unit
NF	-	Naval Facility
NS	-	Naval Station
PG	-	Proving Ground
SAWR	-	Supplementary Airways Weather Reporting (Station)
WBAS	-	Weather Bureau Airport Station
WBO	-	Weather Bureau Office

ST is a two-letter code identifying each of the fifty states.

WBAN # refers to the five-digit number identifying stations operated by United States Weather Services (civilian and military) currently or in the past. A few stations have had no number assigned.

WMO # refers to the five-digit block and station numbers assigned to U. S. stations as authorized by the World Meteorological Organization. Many stations with a WBAN # will have no corresponding WMO number.

LAT, LONG are the latitude and longitude of the station in degrees and minutes. If the station changed coordinates during the period summarized, the location reflects the site with the longest record.

ELEV is the elevation (above sea level) of the station in meters. Reported station elevation was used if the barometric height above sea level was not available. If an elevation change occurred during the period summarized, the elevation reflects the station height for the longest period of record.

PERIOD OF RECORD is the first and last month-year of the summarized period. As an example, 01 38 - 12 44 is read as January 1938 through December 1944.

SUMMARY TYPE identifies each summary according to its format. Each format is.similar to one of the 16 types presented in detail beginning on page I-13.

SUMM FREQ is the summary frequency or the time period in which the summarized data are presented. Abbreviations used are:

M - Monthly.   Data for each calendar month combined and presented on a monthly basis.

S - Seasonal.   Data for the months December through February of the period of record are combined into a winter season, summarized and presented on a seasonal basis. The months March-May, June-August, and September-November are similarly summarized.

A - Annual.   All data for the period summarized together.

MA - Monthly and Annual.

SA - Seasonal and Annual.

MS - Monthly and Seasonal.

MSA - Monthly, Seasonal, and Annual.

IYM - Individual Year-Month. Data are presented for individual months of record.

SP - Special Period. The special period presented is described further in the given summary's Tab #/Remarks column.

TAB #/REMARKS column contains additional identifying or explanatory information. Many of the summaries produced by the Climatic Center and Air Weather Service for a specific project are identified by a tabulation number. A "T" followed by a 4 or 5 digit number identifies a summary produced by the NCC. Similarly, a "TCL" with a number indicates an AWS summary. Not all summaries can be so identified. This number is provided as an aid in requesting a specific tabulation.

Numbers following or in place of a tabulation number refer to remarks listed beginning on page I-9. These remarks are provided if additional information describing a summary is necessary. Examples are summaries with data for hourly or 3-hour periods, specified hours only, combined stations, etc.

C-2. REMARKS

This is a list of descriptive remarks coded by number in the Tab #/Remarks column of the index. Numbers missing were not used.

1. Broken period
2. 3-hourly groups
3. Day-night
4. 0600-1800 LST only
5. 10-12 observations per day, all daylight hours
6. By hours 00, 03, 06, 09, 12, 15, 18, 21 LST
7. See microfilm for broken periods and format
8. Includes flying weather conditions
9. Part "C" only
10. Hours 0600-1200 LST only
11. May-November only
12. Broken period - pre-11/45 data from Point Hope (Stn #26601)
13. Broken period by hourly groups
14. Less 12/59
15. Pre-1939 data from Tin City (Stn #26634)
16. Less 12/70
17. 0500-1600 LST only
18. 2-13 observations daily
19. 0700-1900 LST only
20. Combined data for Douglas AAF (Stn #23001) for 11/42-11/45 and Douglas Apt (Stn #93026) for 11/48-12/54
21. Part "A" only by hourly groups - combined data for Kingman CAA (Stn #93167) for 01/34-12/41 and Kingman AAF (Stn #23108) for 03/43-06/45
22. For hours 0800, 1400, 1700 LST only
23. Direction and speed by visibility, relative humidity $\geq$ 90% and/or precipitation, and relative humidity $\geq$ 90% and no precipitation - August, October, and December only
24. Part "A" only
25. By 2-hourly groups
26. Daylight hours only
27. September-December only
28. By hourly groups
29. For 0900-1600 and 1700-0800 LST
30. Period 01/37-03/38 for Indio (Stn #03105)
31. Precipitation-wind tabulation for April-October
32. By day and night hours on microfilm
33. Periods: July 15-31, August 1-15 for 1000 and 1400 LST
34. No data for 27 months
35. See Edwards AFB
36. Some data from Paso Robles (Stn #23231)
37. All observations by various stability classes
38. See Moffett Field
39. Also contains a contact wind rose
40. Eight directions and calm
41. Includes a percentage graph

42. 1200 LST observations only
43. Some missing data
44. Contains all weather, precipitation, and visibility $\leq$ 6 miles wind tabulations for day and night hours
45. Also called 94A
46. See Farallon Island SE
47A. 0100-0400 LST
47B. 0700-1000 LST
47C. 1300-1600 LST
47D. 1900-2200 LST
47E. 0600-2200 LST
47F. 0700 LST
47G. 1600 LST
47H. 0600-0900 LST
47I. 1600-1800 LST
47J. 0700-0900 LST
47K. 1900-0600 LST
47L. 1000-1500 LST
47M. 1200-2000 LST
47N. 0800-2100 LST
47P. 1100-1300 LST
48. Also contains bimonthly summaries
49. Located in city file
50. Three speed groups
51. June, July, August - daylight hours only
52. Special tables
53. Pre-1944 data from Bolling AAF (Stn #13710)
54. Also known as Chantilly, VA, FAA (pre-Dulles)
55. See Andrews AFB, MD
56. Data for 01/74 from Herndon Apt (Stn #12841)
57. See also Cape Kennedy AFB
58. Tower data - 8 levels (3-150 m)
59. June-August only
60. Data for 09/42-09/45 from Carlsbad AAF (Stn #23006)
61. Data after 07/53 from Key West NAS (Stn #12850)
62. Data thru 1945 from Marianna AAF (Stn #13851)
63. Contains 14 months of data from Morrison Field (Stn #12865)
64. Contains graphical wind rose
65. Tabulated by temperature and relative humidity intervals
66. Seasonal by day and night hours
67. Closed and instrument weather conditions only
68. Less 01/49
69. 24 observations daily
70. 8 observations daily
71. 1 of 3 parts
72. Tabulation by day and night hours for May 1 - September 30 and October 1 - April 30
73. Tabulated for December-March and April-November
74. Data prior to 10/42 and after 10/45 from Sioux City Apt (Stn #14943)

75. For day - clear and cloudy and night - clear and cloudy conditions
76. Also contains a ceiling-visibility tabulation
77. 0700-1900 LST only
78. All weather and 2 relative humidity classes
79. Summer season only - 1957 missing
80. May, August-November only
81. Includes separate wind rose for WSO
82. Four speed categories
83. Monthly tabulation for 0400 and 1400 LST, seasonal tabulation for all observations
84. Some data from Presque Isle AFB (Stn #14604)
85. Four observations per day
86. Semi-monthly periods
87. 1935 data from Boston WBAS (Stn #14739)
88. VFR, IFR, closed conditions
89. Pre-03/1952 data from Paso Robles (Stn #23231)
90. August 1-15 only for hours 1000 and 1400 LST
91. Partial SMOS
92. June, July only for hours 2200L - 0200L
93. April thru December only
94. Less April 1958 and 1960
95. January, April, July, and October only
96. Winter season only
97. Part "C" and "E" only
98. 36 compass points
99. Less October-December 1945 for a 2-hour period after sunrise
100. November 1951 substituted for November 1955
102. For hour groups 07-09, 10-15, 16-18, and 19-06 LST and all hours combined
103. For hours 0100, 0700, 1300, and 1900 LST (individual and all hours combined)
104. Day and night hours, clear and cloudy conditions
106. Pre-02/33 data from Albuquerque WBO (Stn #23073)
108. Precipitation wind rose tabulation
109. All observations by 6 hourly groups
110. For ceiling less than 600 feet and/or visibility less than 1-1/2 miles - also an annual hourly summary
111. Also summarized by month-hour for hours 0200 and 1400 LST
112. Summarized by days 1-15 and 16 to end of month for day and night hours
115A. 1300 LST
115B. 0400 LST
115C. 1000 LST
115D. 1600 LST
115E. 2200 LST
115F. 0700 LST
115G. 0100 LST
115H. 1900 LST
117. See Covington, Kentucky
118. Pre-04/32 data from Oklahoma City WBO (Stn #93954)
119. May to October only

120. . Monthly for 1961-63, individual months 1-4/64
121. Also contains day and night summaries
124. Summary titled Scranton
125. See Wilkes-Barre
126. December-February for 0730 and 1930 LST only
128. Pre-12/44 data from Galveston AAF (Stn #12905)
129. Data for 10/62-12/63 for Greenville-Spartanburg Apt (Stn #03870)
132. February-April and June-September only
133. Pre-03/43 data from English Field (Stn #23047)
134. Post-10/66 data from Fort Wolters
135. Less 6/68
136. For hours 00-23 and 07-22 LST
140. Also contains annual ceiling/visibility tabulation
141. Less 0000 and 0300 LST
142. See Killeen
143. See Dugway PG
144. Data for 1943-49 for Wendover AFB (Stn #24111)
145. 0400-1800 LST
146. See Washington, DC - Dulles International Apt WBAS
147. See Washington, DC - National Apt WBAS
149. 0700-1200 LST
150. Tower data, year-month-level, month-level, and month-level-hour
151. Pre-11/41 data from Paine Field CAA (Stn #24222)
152. 10 observations per day - closed on weekends
153. 10 observations per day - wind speed estimated
155. By 5°F temperature intervals - with and without thunderstorms
157. One speed group - greater than 14 knots
158. Speed classes in Beaufort Force - mean speed by direction in mph
159. Hourly groups for 0600-1600 LST
160. Post-05/55 data from Forest Sherman (Stn #03855)
161. By speed classes and 5°F temperature classes
162. For all hours combined and for hours 0030 and 1230 individually

APPENDIX D

CHEMICAL PROFILES

Chemical Name

Acetaldehyde

CAS Number

75-07-0

Chemical Classification

Aldehyde

Synonyms

Acetic aldehyde, aldehyde, ethanol, ethyl aldehyde

Physical/Chemical Properties

Description:
1. Colorless liquid or gas with irritant, fruity taste
2. Exceedingly volatile (flashes back)
3. Readily oxidized in air, forming explosive peroxides

Boiling point:
20.2° C

Melting point:
-123.5° C

Molecular weight:
44.05

Chemical formula:
C_2H_4O

Vapor pressure:
740.0 mm Hg (20° C)

Refractive index:
$n_D^{20} = 1.33113$

Log partition coefficient (Octanol/H_2O):
0.43

Solubility:
Infinitely soluble in hot H_2O; freely soluble in water, alcohol, ether, benzene, gasoline, solvent naphtha, toluene, xylene, turpentine, oil and acetone

Photochemical reactivity:
        Effective ambient air decay rate: 7.3×10^{-5} s^{-1} (daytime)
                                           No reaction toward O_3

Atmospheric reactivity:
        Transformation products: peroxyacetyl nitrate; formaldehyde

        Reactivity toward OH: 4x butane

        Reactivity toward photolysis: 0.5x formaldehyde

        Major atmospheric precursors: hydrocarbons (C_3+)

        Formation reactivity: equilibrium concentration 5% NMHC

Density:
        0.7834 at 18° C/4° C

Chemical reactivity:
        Highly reactive; exhibits general reactions of aldehydes

Sources of Emissions

Production/processing:
        1. Oxidation of ethylene
        2. Vapor phase oxidation and dehydration of ethanol or
            of propane and butane
        3. Direct conversion of ethylene

Uses:
        1. Chemical intermediate, especially for manufacture
            of acetic acid and peracetic acid
        2. Used in manufacture of synthetic resins, pesticides,
            and pharmaceuticals
        3. Used to make rubber processing chemicals
        4. Used in coating operations in manufacturing of mirrors
        5. Hardening agent in photography
        6. Used in manufacturing of gelatin, glues, casein products
        7. Used as preservative in food products and leather

        Tables D-1 through D-6 and Figure D-1 graphically present
        acetaldehyde production, consumption, and emission data

Storage:
> Bulk storage outside in detached tanks provided with refrigeration and inert gas blanket
>
> Small container storage in detached noncombustible building
>
> Inside storage in standard flammable liquids storage room or cabinet

Transportation:
> Shipped in 1-quart glass pressure bottles, 5- to 55-gallon metal drums, insulated tank cars and trucks, tank barges

Disposition:
> Liquid acetaldehyde may be disposed of by atomizing it in a suitable combustion chamber

Materials damage:
> Liquid acetaldehyde will attack some forms of plastics, rubbers, and coatings

Sampling and Analytical Methods

(Compound very unstable. Requires immediate analysis or derivation.)

1. NIOSH Method S345
   a. Bubbler collection
   b. Derivative from Girard T. reagent
   c. HPLC

   Detection limit:
   > 170-670 mg/m^3 at STP with 60 l sample

   Possible interferences:
   > Other volatile aldehydes

2. Tentative method of analysis for low molecular weight aliphatic aldehydes in the atmosphere (Method K, Appendix A)
   a. Collect in 1% NaHSO$_3$ solution in midget impingers
   b. C$_2$-C$_5$ aldehydes measured by gas chromatographic/flame ionization procedures

   Detection limits:
   > 0.02 ppm at sampling rates of 2 l/min over a 1-hr period

3. Method J from Appendix A

    a. Collection in dinitrophenyl hydrazine (DNPH)
    b. Solvent extraction
    c. Reversed phase HPLC analysis

    Detection limits:
        1-5 ppb for a 40 l sample

    Possible interferences:
        Reagents must be carefully prepared to avoid significant contamination

Material Damage

    Liquid acetaldehyde will attack some forms of plastics, rubbers, and coatings

Permissible Exposure Limits

	OSHA	ACGIH
TWA	200 ppm (360 mg/m^3)	100 ppm (180 mg/m^3)
Ceiling		150 ppm (270 mg/m^3)
TLV (odor)		2.3 ppm

Human Toxicity

    Acute toxicity:
        TC_{LO} by inhalation is 134 ppm; produces narcosis in humans

    Chronic toxicity

        Mutagenicity--Mutagenesis/genetic toxicity testing ongoing in FY83 (U.S. DHHS 1983)

Other chronic toxicity:
Biochemical/cellular/tissue effects, pharmacokinetics/
metabolism effects, and systemic/organ toxicity testing
ongoing in FY83 (U.S. DHHS 1983)

Acetaldehyde is an eye, nose, and throat irritant and
can cause skin burns and dermatitis

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Chemical Name

Acrolein

CAS Number

107-02-8

Chemical Classification

Aldehyde (unsaturated)

Synonyms

Acraldehyde, acrylic aldehyde, allyl aldehyde, 2-propenal, ethylene aldehyde, acrylaldehyde

Physical/Chemical Properties

Description:
Colorless to yellowish, watery, volatile liquid; powerful lacrimator

Boiling point:
52.5° C

Melting point:
-86.95° C

Molecular weight:
56.06

Chemical formula:
C_3H_4O

Vapor pressure:
288.2 mm Hg at 25° C
215 mm Hg 20° C

Refractive index:
$n_D^{20} = 1.4013$

Solubility:
Very soluble in water (200 g/l at 20° C) and many organic liquids

Photochemical reactivity:
    Effective ambient air decay rate: 1.6×10^{-4} s^{-1} (daytime)
                                        5.0×10^{-6} s^{-1} (nighttime)

    Reactivity toward: OH is 0.5x butane
                        O_3 is 0.5x propylene
                        photolysis is 5x formaldehyde

Vapor density:
    1.94 (air = 1)

Density:
    0.84 g/cm^3 at 20° C/4° C

Chemical reactivity:
    Extremely reactive with oxidizing materials; can be stored
    only in the presence of stabilizers (0.1% hydroquinone);
    atmospheric oxygen, alkalies, mineral acids and peroxides can
    trigger violent polymerization reactions

Environmental Fate

    Total release rate of acrolein to the environment is not known.
    Fugitive acrolein emissions come from industrial processes, and
    acrolein is formed in the environment by burning tobacco, forest
    fires, and by heating fats or glycerine

Sources of Emissions

Production:
    1. Pre-1959: vapor phase concentration of acetaldehyde
        and formaldehyde
    2. Post-1959: direct catalytic vapor phase oxidation
        of propylene (or allyl alcohol)
    3. Heat glycerol with magnesium sulfate
    4. Synthesized from propylene with bismuth-phosphorous-
        molybdenum catalyst

Uses:
    1. Unisolated acrolein is an intermediate in the production
        of acrylic acid and its derivatives
    2. Refined, or isolated acrolein end-uses:
        a. Production of synthetic glycerin
        b. Methionine and methionine hydroxy manufacture
            (poultry feed supplements)

       c. Used as fungicide to prevent slime (especially in paper industry)
       d. Denaturant in alcohol
       e. Tissue fixative
       f. Used in leather tanning
       g. Aquatic herbicide and to control growth of microbes in feed lines of wastewater treatment and in liquid fuels
       h. Used to make tear gas
  3. Present in:
       a. Smog
       b. Fuel combustion products
       c. Woodfire smoke
       d. Cigarette smoke

Tables D-7 through D-11 and Figure D-2 graphically present acrolein production, consumption, and emission data

Storage:
    Uninhibited acrolein is not to be stored under any circumstances. Outside or detached storage preferable. Inside storage in a standard flammable liquids storage room or cabinet. No alkaline or oxidizing materials are to be stored with acrolein

Disposition:
    Acrolein wastes occur in both manufacturing and processing plants

    Nonreusable acrolein is contained in waste gases and process water from synthesis plants or occurs in the form of defective batches and superposed reserves

    Aqueous wastes with low concentrations of acrolein are usually neutralized with sodium hydroxide and fed to a sewage treatment plant for biological secondary treatment

    Concentrated wastes are reprocessed whenever possible or burned in special waste incinerators

Sampling and Analytical Methods

  1. NIOSH Method P&CAM 118, "Acrolein in Air"
      a. Collection in midget impingers containing the absorbing solution or reagent

b. Complexation in presence of mercuric chloride
c. Colorimetric analyses
    Detection limits:
        1-30 μg/10 ml
    Possible interferences:
        Slight interference from dienes
        Samples must be analyzed soon after collec-
          tion due to 2-hour limit on color development

2. NIOSH Method P&CAM 211, "Acrolein in Air."

a. Collection in midget impingers with 1% aqueous $NaHSO_3$
b. Reaction with 4-hexylresorcinol
c. Colorimetric analyses
    Detection limits:
        0.01 ppm/50 l air sample
        1-30 μg/10 ml sample
    Possible interferences:
        Slight interferences from dienes.
        Samples should be analyzed soon after collec-
          tion, unless refrigerated (for up to 48 hours)

3. Method J from Appendix A

a. Collection in dinitrophenylhydrazine (DNPH)
b. Solvent extraction of DNPH derivatives
c. Reverse phase HPLC analysis

    Detection limits:
        1-5 ppb (40 l sample)

    Possible interferences:
        Blank levels of aldehydes (usually formaldehydes)
        will usually determine the detection limits

        Reagents must be carefully prepared to avoid
        significant contamination

        Analysis within 24 hours is recommended

Materials Damage

Contact of acrolein with oxidizing agents, acids, alkalies, and ammonia may cause fires and explosions

Permissible Exposure Limits

	OSHA	ACGIH
TWA	0.1 ppm (0.25 mg/m^3)	0.1 ppm (0.25 mg/m^3)
Ceiling		0.3 ppm (0.8 mg/m^3)
Odor Threshold		0.2 to 15 ppm reported

Human Toxicity

Acute toxicity:
The LC_{LO} for inhalation (humans) is 153 ppm/10 minutes. Acrolein is a severe pulmonary irritant and lacrimating agent. As a liquid, acrolein causes severe corrosive burns on the skin and mucous membranes

Chronic toxicity:

Carcinogenesis--Carcinogenesis testing to be completed by FY83 (U.S. DHHS 1983)

Other chronic toxicity:
Acrolein is on test in FY83 for biochemical, cellular, and tissue effects, and for pulmonary toxicity (U.S. DHHS 1983)

Acrolein causes lacrymation and respiratory tract irritation and can cause CNS damage

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Chemical Name

Acrylonitrile

CAS Number

107-13-1

Chemical Classification

Substituted allyl; nitrile

Synonyms and Trade Names

ACN, acrylon, acrylonitrile (DOT), acrylonitrile (8CI), acrylonitrile monomer, AN, carbacryl, cyanoethylene, ENT 54, Fumi-grain, Millers Fumigrain, propenenitrile, 2-propenenitrile, TL 314, VCN, Ventox, vinyl cyanide

Physical/Chemical Properties

Description:
Volatile, colorless liquid; explosive, flammable; characteristic odor resembling peach seeds

Boiling point:
77.5° C

Melting point:
-83.5° C

Molecular weight:
53.06

Chemical formula:
C_3H_3N

Vapor pressure:
113.8 mm Hg at 25° C; 83 mm Hg at 20° C

Vapor density:
1.83 (air = 1.0)

Density:
0.8060 at 20° C/4° C

Refractive index:
$$n_D^{25} = 1.3888$$

Solubility:
Acrylonitrile is moderately soluble in water (50 g/l at 20° C); it is soluble in acetone and benzene, and is miscible with ethanol and ether

Octanol/water partition coefficient:
-0.92

Photochemical reactivity:
Olefins generally, as a class, enhance atmospheric oxidation reactions. Acrylonitrile has been found to be reactive, with an atmospheric half-life of 9-10 hours

Density:
806 g/l at 20° C

Chemical reactivity:
Reacts with oxidizing materials. Cannot be stored without the addition of polymerization inhibitors

Environmental Fate

The atmospheric half-life of acrylonitrile is sufficiently long to allow for its atmospheric transport, especially when coupled with its high volatility and its low solubility in water

Sources of Emissions

Production:
1. SOHIO process: oxidation of propylene in the presence of ammonia (ammoxidation of propylene) using either a bismuth phosphomolybdate or uranium-base catalyst (the only process used commercially in the United States)
2. Addition of hydrogen cyanide to acetylene using cuprous chloride catalyst
3. Catalytic reaction of propylene with nitrous oxide

4. Reaction of ethylene oxide with hydrogen cyanide followed by catalytic dehydrogenation of ethylene cyanohydrin

5. Ammoxidation of propane

Uses:
1. Acrylic and Modacrylic Fibers
   More than 60% of these fibers are used in apparel. Carpeting is the second largest use. Home furnishing uses include blankets, draperies, and upholstery. Industrial uses include sandbags, filter cloths, tents, and tarpaulins. The fibers are also used in synthetic hair wigs

2. ABS Resin
   Major markets are pipes and pipe fittings, and automotive components. Other important markets are large appliances, housing for business machines and telephones, recreational vehicle components, toys, sporting goods, sheeting material for luggage, and food containers

3. SAN Resin
   Primary uses are for drinking tumblers and other houseware items, for automobile instrument panels, instrument lenses, and food containers

4. Nitrile Elastomers
   Major uses are in rubber hose, seals, gaskets, latex, adhesives, polyvinyl chloride blending, paper coatings, and pigment binders

5. Adiponitrile
   It is hydrogenated to hexamethylenediamine, which is used to produce nylon

6. Acrylamide
   The largest use is in the production of polyacrylomides for waste and water treatment flocculants. Other acrylamide products are used to aid sewage dewatering, and for papermaking strengtheners and retention aids

7. Nitrile Barrier Resins
   They are used in the manufacture of non-beverage containers for glue, nail polish, correction fluid, air freshener, contact lenses, tooth brushes, and combs

The major sources of acrylonitrile emissions in the United States are monomer and polymer production facilities. The estimated acrylonitrile emissions from these facilities are shown in Tables D-12 and D-13. Table D-14 gives spill hazards for acrylonitrile.

TABLE D-12. ESTIMATED ACRYLONITRILE EMISSIONS FROM MONOMER AND POLYMER PRODUCTION FACILITIES

Production facility	Estimated acrylonitrile emissions (Mg/yr)*
Monomer	802
ABS-SAN resin	1424
Acrylic and modacrylic fiber	1276
Nitrile elastomer	295
Adiponitrile	59
	3856

* Mg - millions of grams

Source: U.S. EPA 1982

TABLE D-13. MONOMER RESIDUE IN END-PRODUCTS OF ACRYLONITRILE

Product name	Usage	Monomer residue (ppm)
Acrylic and monacrylic fiber	Fabric	<1
Hycar	Rubber	0-100
Kralastic and paracril	Resin	50
UCAR-380	Latex	250
UCAR-4358	Latex	750
Acrylamide monomer	See Figure 1	50-100
Polyacrylamide	See Figure 1	1
ABS Resin	Packaging	24
SAN Resin	Containers	3-7
SAN Resin	Containers	2-5

Source: U.S. EPA 1982

Storage:
Outside or detached storage preferable

Inside storage in standard flammable liquids storage
room or cabinet

Uninhibited acrylonitrile not to be stored under any
condition

Outside tanks should be above-ground and surrounded by
dikes of sufficient capacity to hold entire tank con-
tents

Transport:
TABLE D-14. HAZARDS OF ACRYLONITRILE TRANSPORTATION*

Hazard parameter	Barge	Truck	Rail
Spill Pool radius (m)	61.0	17.1	31.7
Hazard radius (m)	122	38.4	68.3
Hazard area (m^2)	46,700[†] 5,460**	4,450[#]	13,400[#]
Relative exposure (%)-- urban/rural	8/92	23/77	27/73
Expected number of annual spills	0.0117	0.063	0.17
Probability of ignition following spill	0.30	0.25	0.40

* Calculations are based upon the assumption that each mode
  of transportation handles 100 percent of the quantity
  shipped, and that a total of 73,000 Mg per year of acrylo-
  nitrile is shipped between two points
[†] Area affected by spills into water which ignite. Assumes
  entire spill quantity contributes to burning pool
[#] Area affected by spills on land which ignite. If no
  ignition occurs, the exposed land area is equivalent
  to the pool spill area (R^2 spill)
** For spills into water which do not ignite. The water
  toxicity hazard distance (meters) measured downstream
  from spill location for a 152 m wide, 3.05 m deep river
  flowing at 0.70 m/s. Assumes vertical dispersion rate at
  0.30 m/min until uniform mixing is achieved throughout the
  entire depth of the river. Thereafter, plug flow is assumed
  with no synergistic or antagonistic reaction between
  the pollutant and the receiving body of water. For this
  situation, the entire spill quantity contributes to water

Source: U.S. EPA 1982

Disposition:
 Acrylonitrile wastes are to be expected only in petro-
 chemical plants and the frequently attached polymer
 production. Due to their quantity, they require special
 disposal provisions

 Aqueous wastes with low contents are flushed into the
 sewerage system and biologically treated in sewage
 treatment plants. However, it will first have to be
 determined whether other constituents are present which
 could interfere with the degradation process. Undegraded
 remainders can be removed by filtration through activated
 charcoal

 Concentrated wastes, which are mostly of a very complex
 nature, are turned over to special waste disposal facil-
 ities, if reproccessing appears uneconomical

 Tables D-15 through D-17 give monitoring and analysis data
 for acrylonitrile

Sampling and Analytical Methods

1. NIOSH method P&CAM 202 "Acrylonitrile in Air"
   a. adsorption on Carbosieve B
   b. desorption with methanol
   c. gas chromatographic determination

   Detection limits:
    40-1100 mg/m^3 in a 20 l sample

   Possible interferences:
    High humidity decreases loading capacity of the
     sorbent tube
    Any compound that has the same retention time as
     acrylonitrile

2. NIOSH method S156 for "Acrylonitrile"
   a. adsorption on charcoal
   b. desorption with methanol
   c. gas chromatographic analysis

   Detection limit:
    17.5-70.0 mg/m^3 with a 20 l sample
    Probable useful range is 4.5-13.5 mg/m^3

Possible interferences:
Humidity high enough to cause condensation in the
charcoal tube will cause inefficient trapping of
vapors
Any compound present which has the same retention
time as acrylonitrile

3. Method B from Appendix A

    a. Whole air collection in canister cryogenic concentration
    b. Gas chromatographic/flame ionization detection (GC/FID)

    Detection limit:
    0.1 ppb for a 100 ml sample

    Possible interferences:
    Storage time greater than a week not recommended
    Reactive and water-soluble compounds not readily
    analyzed
    If possible, a fluid GC/FID should be used to
    avoid sample storage problems

4. Method F from Appendix A

    a. Adsorption on carbon molecular seives
    b. Thermal desorption into canister
    c. Analysis by gas chromatography/flame ionization detection
    or gas chromatography/mass spectrometry

    Detection limits:
    0.01-1.0 ppb in a 20 l sample

    Possible interferences:
    High temperature (350° C) required for desorption
    may decompose labile compounds

5. Table D-18 lists recovery efficiency of alternate solvents
    to use of methanol

TABLE D-18. RECOVERY OF ACRYLONITRILE FROM VARIOUS SOLVENTS

Solvent	% Recovery
Methanol	ca. 50%
Acetone	73.5 + 5.3%
2% acetone in CS_2	95.5 + 7.9%
2% acetone in CS_2	94%
CS_2 (2 ml)	58%
CS_2 (4 ml)	75%

Source: U.S. EPA 1982

Materials Damage

Acrylonitrile may not be stored without polymerization inhibitors

Permissible Exposure Limits

	OSHA	NIOSH	ACGIH
TWA	2 ppm	4 ppm/10 hr	2 ppm (4.5 mg/m^3)
Ceiling	10 ppm/15 min		(human carcinogen)

Odor perception: 21.4 ppm

Human Toxicity

Acute Toxicity:
    Occupational exposures of 16 to 100 ppm for 20 to 45 minutes produced nasal irritation, upper respiratory tract tightness

    Acrylonitrile mixed with carbon tetrachloride caused toxic epidermal necrolysis

Chronic Toxicity:

    Carcinogenesis--On test in FY1983 for carcinogenesis (U.S. DHHS 1981)

    Occupational exposures may be associated with an excess of lung and colon cancer

Mutagenesis--Mutagenesis/genetic toxicity testing to be
completed in FY1983 (U.S. DHHS 1981)

Other Chronic Toxicity:
On test for pulmonary toxicity in FY1983 (U.S. DHHS 1981)

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Chemical Name

Allyl Chloride

CAS Number

107-05-1

Chemical Classification

Organic halide

Synonyms

3-Chloro-1-propane, 3-chloro-propylene, chlorallylene, 3-chloroprene

Physical/Chemical Properties

Description:
Colorless to strawberry-colored liquid

Boiling point:
44.6° C

Melting point:
-134.5° C

Molecular weight:
76.5

Chemical formula:
C_3H_5Cl

Vapor pressure:
295 mm Hg 20° C
359 mm Hg 25° C

Refractive index:
1.416

Solubility:
Insoluble in water
0.36 wt % 20° C
Soluble in alcohol

Density:
0.94 g/cm^3

Vapor density:
2.64 (air = 1)

Chemical reactivity:
Very reactive and widely usable as a starting material
and intermediate in organic synthesis

Transformation products in the atmosphere include
2-chloro-acetaldehyde and formaldehyde

Sources of Emissions

Production/processing:
Production in 1978 was estimated as 330 million lb

Process emissions (lb/year)	Producer	Location
516,000	Dow Chemical Co.	Freeport, TX
226,000	Shell Chemical Co.	Deer Park, TX
226,000	Base Chemicals	Norco, LA

Uses:
Allyl chloride is used as a monomer in the production
of various plastics, resins, surface coatings, and as a
chemical intermediate for glycerol, epichlorohydrin, and
allyl alcohol

No emissions data were available

Storage emissions from storage operations have been
estimated as 46,200 lb/year

Disposition:
With the exception of defective batches, no concentrated
wastes are reported

Sampling and Analytical Methods

Sampling methods:
A known volume of air is drawn through a charcoal tube
to trap the organic vapors present

NIOSH Manual of Analytical Methods number S116

Analytical methods:
    The analyte is desorbed with benzene and an aliquot of
    the desorbed sample is injected into a gas chromatograph;
    NIOSH Manual of Analytical Methods number S116

Detection limits:
    For a 100 l sample size, the detector sensitivity
    is 0.5 to 10 mg/m^3

Possible interferences:
    1. High humidity causes inefficient trapping of organic
       vapors
    2. Interference from the presence of the desorbant
    3. Compounds present with the same column retention
       time

Permissible Exposure Limit

OSHA Standard
    1 ppm (3 mg/m^3) TWA
NIOSH recommendation
    3 ppm/15 min ceiling (9 mg/m^3)

Human Toxicity

Chronic Toxicity:

    Carcinogenicity--There is inadequate evidence in humans, and in
    experimental animals tumors were not induced in a 6-month
    study (3 ppm, inhalation)

    Mutagenicity--Allyl chloride was mutagenic in Salmonella TA 100
    and TA 1535

    Teratogenicity--Reproductive and developmental toxicity are on
    test in FY83

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Chemical Name

Arsenic

CAS Number

7440-38-2

Chemical Classification

Elemental metal

Synonyms

Arsen; arsenic black; grey arsenic; metallic arsenic

Physical/Chemical Properties

Description:
Grey to black brittle, crystalline or amorphous solid

Boiling point:
613° C (sublimes)

Melting point:
817° C

Atomic weight:
74.92

Atomic formula:
As

Solubility:
Insoluble in water; soluble in nitric acid

Photochemical reactivity:
No photochemical reactivity

Density:
    5.727 g/cm^3 20° C

Chemical reactivity:
    Metallic arsenic is stable in dry air; arsenic vapor
    does not combine directly with hydrogen to form hydrides.
    Metallic arsenic is not readily attacked by water, alka-
    line solutions or non-oxidizing acids

Sources of Emissions

Production:
    Approximately 70 million lb of arsenic and inorganic
    arsenic compounds are produced in the United States
    annually. Table D-19 lists the location and companies
    producing arsenic compounds. Table D-20 lists the esti-
    mated arsenic emissions in the United States by source.
    Arsenic trioxide is the source of 97 percent of arsenic
    compounds

Uses:
    Elemental arsenic and arsenic compounds are used in
    pesticides, glass, ceramics, paints, dyes, nonferrous
    alloys, wood preservatives, etc.

    Emission factors for mining, industrial sources, process-
    ing and consumptive uses have been calculated as follows:

Source	Emission Factor
Mining	0.2 lb/ton arsenic in ore
Copper smelter	5 lb/ton of copper
Lead smelter	0.8 lb/ton of lead
Zinc smelter	1 lb/ton of zinc
Cast iron	0.01 to 0.02 lb/ton of metal charged
Nonferrous alloys	1 lb/ton of arsenic processed
Pesticide production	20 lb/ton of arsenic processed
Glass production	0.2 lb/ton of glass produced
Others (paint, pharma- ceuticals, semicon- ductors, pyrotechnics, wood preservatives, etc.)	3 lb/ton of arsenic processed
Cotton ginning processing	4 lb/10^3 bales of cotton ginned

TABLE D-19. PRODUCTION OF ARSENIC COMPOUNDS

Location	Company
California	
Cucamunga	Will Ross (G. D. Searle)
Newark	" "
Santa Clara	Airco
South Gate	Los Angeles Chemicals
Georgia	
Morrow	Will Ross (G. D. Searle)
Fort Valley	Woolfolk Chemicals
Illinois	
Joliet	Will Ross (G. D. Searle)
North Chicago	Abbott Labs
Rockford	Apache Chemicals
Massachusetts	
Gloucester	Will Ross (G. D. Searle)
Missouri	
St. Peters	Monsanto
New Jersey	
Bayonne	Dimensional Pigments
Bayonne	Rona Pearl
Bound Brook	Blue Spruce
East Rutherford	Will Ross (G. D. Searle)
Jersey City	City Chemicals
Somerset	W. A. Cleary
Vineland	Vineland Chemicals
Oklahoma	
Miami	Eagle-Picher
Quapaw	"
Tulsa	Ozark-Mahoning (Pennwalt)
Pennsylvania	
Myerstown	Rohm and Haas
Tennessee	
Memphis	Osmose Wood Pres.
Texas	
Bryan	Pennwalt
Greens Bayou	Diamond-Shamrock
La Porte	Will Ross (G. D. Searle)
Washington	
Tacoma	Pennwalt
Wisconsin	
Marinette	Ansul

Source: Mason et al. 1979

TABLE D-20. ESTIMATED ARSENIC EMISSIONS IN U.S.--1974

Source	Number of Plants	Inorganic Arsenic Emissions kkg/Year	Percent Total Emissions
Copper smelters	15	2712	61.1
Lead smelters	6	63	1.4
Zinc smelters	6	73	1.6
Production of arsenical compounds	25	154	3.5
Application of inorganic arsenical pesticides	N/A	399*	9.0
Glass production	325	363	8.2
Coal burning - power plants above 25 megawatts	369	526	11.9
Other	-	109	2.5
Misc. (cotton gins, non-ferrous alloys, inorganic chemicals)	-	36*	.8
Total		4435	100.0%

Source: Mason et al. 1979

Coal-fired plants, pesticide production and use, and copper smelting are all significant sources of atmospheric arsenic. EPA reports that smelter emissions result in the most arsenic exposure by air to the greatest number of persons

Disposition:
Arsenic-containing wastes in the form of sludge occur during the metallurgical processing of arsenic-containing ores. Arsenic contamination of the environment occurs faster than it can be dissipated by natural processes. The emission factor for sewage and sludge containing arsenic has been calculated as 0.2 lb/ton. Airborne waste emissions were addressed under emission factors

Sampling and Analytical Methods

Particulate Arsenicals

Sampling methods:
Particulate arsenicals are collected on a 37 mm polytetrafluoroethylene-backed membrane filter at 1.5 lpm

Method number P&CAM 320

Analytical method:
The arsenicals are extracted ultrasonically and the arsenical species are separated chromographically. Hydrides of each species are generated and quantitated by AAS detection using quartz furnace atomization

Method number P&CAM 320

Detection limits:
This method was tested over the range of 5-20 ug/m^3 using a 300 l sample

Possible interferences:
Any arsenical compound with the same column retention time as the arsenical of interest is an interference

Additional methods for sampling and analysis of arsenic are:
Arsenic and compounds (as AS) in air (NIOSH Method number S309)

Inorganic arsenic in air (P&CAM 346)

Source: NIOSH Manuals of Analytical Methods

Permissible Exposure Limits

OSHA Standard
0.5 mg/m^3 8-hr TWA as arsenic (organic);
10 μg/m^3 8-hr TWA (inorganic)

Human Toxicity

Acute toxicity:
Acute arsenic poisoning can occur from accidental or intentional ingestion and can result in death of the victim

Chronic toxicity:

Carcinogenicity--there is sufficient evidence that skin cancer in humans is causually associated to inorganic arsenic compounds. Case reports have suggested an association between exposure to arsenic compounds and blood dyscrasias and liver tumors

Mutagenicity--humans who have been exposed to sodium arsenite have shown chromosomal defects

Teratogenicity--birth defects have been demonstrated in animals injected with arsenic. The evidence in humans is not available

Other chronic toxicity:

Neurological effects--arsenic exposure in humans can produce peripheral nerve damage and altered electrocardiograms

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Chemical Name

Asbestos

CAS Number

1332-21-4

Chemical Classification

Natural fibrous silicate

Synonyms

Asbestos fiber, asbestos fibre

Physical/Chemical Properties

Description:
Fibrous mineral that can be woven; good flexing and tensile strengths. There are two major groups of asbestos: serpentine (chrysotile) and amphibole. Chrysotile is the major type of asbestos used in the manufacture of asbestos products.

Properties of asbestos fibers:

Type	Name	CAS #	Formula
Serpentines	Chrysotile	12001-29-5	$Mg_3Si_2O_5(OH)_4$
Amphiboles	Amosite	12172-73-5	$(MgFe)_7Si_8O_{22}(OH)_2$
	Crocidolite	12001-28-4	$Na_2(MgFe)_5Si_8O_{22}(OH)_2$
	Anthophyllite	17068-78-9	$(MgFe)_7Si_8O_{22}(OH)_2$
	Tremolite	14567-73-8	$Ca_2Mg_5Si_8O_{22}(OH)_2$
	Actinolite	13768-00-8	$Ca_2(MgFe)_5Si_8O_{22}(OH)_2$

Other properties of asbestos fibers: See Table D-21

Synonyms:
Chrysotile: serpentine, 7-45 asbestos, Avibest C, Cassiar K, Calidria RG 144, Calidria RG 600
Amosite: mysorite
Crocidolite: --

Anthophyllite: Asbolen asbestos, ferroanthophyllite

Tremolite: Silicic acid, calcium magnesium salt (8:4)

Actinolite: --

Chemical reactivity:
Asbestos has a high fusion temperature; it is resistant
to thermal degradation and chemical attack

Environmental Fate

Asbestos fibers are released into the environment from the natural
occurrence of asbestos in the earth

Asbestos minerals are emitted into the atmosphere and water systems
from the mixing and milling of asbestos ores

Atmospheric asbestos is limited because the mineral fibers and dust
are quickly deposited by means of precipitation, becoming bound to
soil or sediments

The general population is exposed to asbestos fibers from air,
beverages, drinking water, food, pharmaceutical and dental prepar-
ations, and asbestos-containing consumer products. Families of
asbestos workers have been exposed to high-fiber levels through
contaminated clothing that was brought home for laundering

Sources of Emissions

Production:
Naturally, from asbestos ore and counterpart rock
Asbestos mining: run-off from waste tailings in dry mining
run-off from wet mining
iron ore mining
Approximately 200 million pounds were produced in 1979

Uses:
Asbestos cement products, manufactured by wet processes
Electrical insulation
Thermal insulation
Asphalt and vinyl flooring, adhesives

Papers, millboards, roofing felts

Asbestos textile industry, fireproof and acidproof fabrics

Brake linings, clutch facings and packings

Putties, molding compounds, roof coatings, welding rods, paints, calking compounds, fillers

For filtration (wines, juices, beers, whiskey)

For asphalt paving

In reinforcing plastics

Missile work--satellites, special packings in atomic energy equipment

Storage:
   Milled asbestos fiber is usually stored and shipped in bags (which themselves become sources of emissions)

Transportation:
   Emissions from open-truck movement of asbestos ore from mine to mill

   Emissions from shipment of milled asbestos fiber and asbestos-containing products

Disposition:
   Emissions into run-off waters from asbestos mines, deposited in soils

   Emissions from brakes lined with asbestos

   Emissions from demolition of buildings with asbestos insulation

   Emissions from manufacture and use of products containing asbestos

   Asbestos-containing wastes occur as residues, collected dusts and sludges, and are often disposed of in open dump along with municipal wastes

   Asbestos production, consumption, and exposure data are given in Tables D-22 through D-28

TABLE D-22. WORLD PRODUCTION OF ASBESTOS

Year	World production (million kg)	% Canada	% USSR
1960	2 210	45	29
1970	3 490	44	30
1973	4 093	41	31
1974	4 115	40	33
1975	4 560	23	48
1976	5 178	29	44

Source: IARC 1980

TABLE D-23. ASBESTOS DISTRIBUTION BY END USE, GRADE, AND TYPE IN THE U.S., 1974
(million kg)

	Chrysotile	Crocidolite	Amosite	Anthophyllite	Total
Asbestos cement pipe	168	33	0.9	0.18	202
Asbestos cement sheet	82		3.9		86
Flooring products	139				139
Roofing products	66		1.5		67
Packing & gaskets	26	0.09			26
Insulation, thermal	6.6		1.6		8
Insulation, electrical	4.2				4
Friction products	72			0.18	72
Coatings and compounds	34				34
Plastics	15	0.18		0.63	16
Textiles	18				18
Paper	57	0.18			57
Other	33	0.36	0.45		34
Total					763

Source: IARC 1980

TABLE D-24. LENGTHS OF ASBESTOS FIBERS IN AIR NEAR VARIOUS U.S. INDUSTRIES

Operation	Fibre type	Median length (µm)	% > 5 µm
Textile	chrysotile		
Fibre preparation & carding		1.4	4
Spinning, twisting, weaving		1.0	2
Friction	chrysotile		
Mixing		0.9	2
Finishing		0.8	2
Asbestos-cement pipe	chrysotile		
Mixing		0.9	2
Finishing		0.7	1
Pipe insulation	amosite		
Pipe forming		4.9	51

Source: IARC 1980

TABLE D-25. ASBESTOS PRODUCERS--1976

Location	Company	Comments
Alaska		
near Eagle	Tanana Asbestos	Drilling Operation in Progress
Arizona		
El Dorado Mine, Gila County	Jacquays Mining	
California		
Copperopolis	Calaveras Asbestos	
Fresno County	Atlas Asbestos	
San Benito County	Union Carbide	
North Carolina		
Newdale	Powhaten Mining	May be inactive, Anthophyllite asbestos
Vermont		
Lowell	Vermont Asbestos	

Notes - All asbestos mined is chrysotile except at the North Carolina location.

Source: Mason et al. 1979

TABLE D-26. ASBESTOS DISTRIBUTION BY TYPE, 1974 (Short tons)

	Crocidolite	Amosite	Anthophyllite	Total asbestos
Asbestos cement pipe	36,400	1,100	200	222,900
Asbestos cement sheet	—	4,300	—	94,500
Flooring products	—	—	—	152,500
Roofing products	—	1,700	—	76,500
Packing and gaskets	100	—	—	23,800
Insulation, thermal	—	1,300	—	9,100
Insulation, electrical	—	—	—	4,700
Friction products	—	—	200	79,500
Coatings and compounds	—	—	—	27,900
Plastics	200	—	700	17,600
Textiles	—	—	—	20,400
Paper	200	—	—	63,300
Other	400	500	—	37,300
Total	37,300	9,400	1,100	945,500

Source: Mason et al. 1979

TABLE D-27. ASBESTOS WORKERS EXPOSED

Asbestos mine and mill workers
Construction workers
Shipyard workers
Workers involved in the manufacture of:
    Asbestos textiles
    Insulation materials
    Acoustical products
    Asbestos cement, tile, cement powders

Source: Mason et al. 1979

TABLE D-28. SELECTED ASBESTOS CONSUMERS

Location	Company	Products
Alabama		
Ragland	CAPCO	Asbestos-concrete pipe
Arkansas		
Van Buren	CAPCO	Asbestos-concrete pipe
California		
Pittsburg	Johns-Manville	Asbestos paper
Connecticut		
Stratford	Raybestos-Manhatten	Textiles, friction materials*
Illinois		
Kankakee	Armstrong-Cork	Roofing and Tile
Louisiana		
New Orleans	National Gypsum	Asbestos-concrete sheet
Maine		
E. Walpole	Hollingsworth and Vose	Asbestos paper
Billerica	Johns - Manville	Asbestos-concrete sheet
Missouri		
St. Louis	Certain-Teed	Asbestos-concrete pipe
St. Louis	GAF	Asbestos-concrete sheet
New Hampshire		
Nashua	Johns - Manville	Asbestos-concrete sheet
Tilton	Johns - Manville	Asbestos paper
New Jersey		
Manville	Johns - Manville	Multi-products *
New York		
Fulton	Armstrong Cork	Asbestos paper
North Carolina		
Marshville	Raybestos - Manhatten	Textiles, friction materials
N. Charleston	Raybestos - Manhatten	Textiles, friction materials
Ohio		
Ravenna	Flintkote	Asbestos-concrete pipe *
Pennsylvania		
Ambler	Nicolet	Asbestos-concrete sheet
Erie	GAF	Asbestos paper *
Erie	GAF	Roofing and Tile
Whitehall	GAF	Asbestos paper *
Texas		
Denison	Johns - Manville	Asbestos-concrete pipe *

Source: Mason et al. 1979

Sampling and Analytical Methods

1. NIOSH method P&CAM 239 for "Asbestos Fibers in Air"
   a. Filter collection
   b. Microscopic count

   Detection limits:

   0.1 - 60 fibers/cm^3

   Possible interferences:

   In an atmosphere known to contain asbestos, all particulates with a length to diameter ratio of 3 to 1 or greater, and a length greater than 5 micrometers should, in the absence of other information, be considered to be asbestos fibers and counted as such.

2. NIOSH method P&CAM 309 for "Chrysotile"
   a. Collection on membrane filter
   b. Redisposition on silver membrane filters
   c. X-ray diffraction

   Detection limits:

   25 - 2500 μg/m^3 for an 800 l sample

   Possible interferences:

   Antigorite, the massive form of chrysotile, present in quantities >10%

   Chlorite interferes with both primary and secondary peaks of chrysotile unless the instrument has good resolution

   Kaolinite interferes with the primary peak of chrysotile so the secondary peak must be used.

   The presence of iron in sample results in X-ray fluorescense which can be avoided by using a diffracted beam monochromator

3. For "Chrysotile in Bulk Samples," see NIOSH method P&CAM 245

Permissible Exposure Limits

	OSHA	ACGIH
TWA	2 fibers longer than 5 μm/8 hr	amosite: 0.5 fibers >5 μm/cc chrysotile: 2 fibers >5 μm/cc crocidolite: 0.2 fibers >5 μm/cc other forms: 2 fibers >5 μm/cc
Ceiling	10 fibers longer than 5 μm/cc	

Human Toxicity

Chronic toxicity:

Asbestosis--Asbestos dusts and asbestos-containing dusts are among the fibrogenic dusts which, with the formation of connective tissue, can simultaneously cause pneumonoconiosis. Fibers of up to 250 μm in length can reach the alveoli. Longer fibers are always more dangerous than short ones

Sometimes the action of asbestos can cause irritation of the conjunctiva, gullet, and mucous membrane of the larynx. Fine asbestos fibers that reach the digestive tract are occasionally capable of penetrating the stomach and intestinal walls, reaching the blood stream and migating through the body with the flow of blood. They can even pass through the placenta

Carcinogenicity--Occupational exposure to chrysotile, amosite, anthophyllite, and mixtures containing crocidolite has resulted in a high incidence of lung cancer. A predominantly tremolitic material mixed with anthophyllite and small amounts of chrysotile has also caused an increased incidence of lung cancer. Pleural and peritoneal mesotheliomas have been observed after occupational exposure to crocidolite, amosite, and chrysotile asbestos. Gastrointestinal tract cancers were increased in groups exposed occupationally to amosite, chrysotile, or mixed fibers containing crocidolite. An excess of cancer of the larynx was also observed in exposed workers. Mesotheliomas have occurred in individuals living in the neighborhood of asbestos factories and crocidolite mines, and in persons living with asbestos workers. Both cigarette smoking and occupational exposure to asbestos fibers increase lung cancer incidence independently. When present together, they act multiplicatively

177

On test in FY1983 for biochemical/cellular/tissue effects, and for immunological and pulmonary toxicity, clinical toxicology and epidemiology (U.S. DHHS 1983)

Acute/chronic toxicity, biochemical/cellular/tissue effects, and immunological and pulmonary toxicity testing to be started in FY1983 (U.S. DHHS 1983)

Acute/chronic toxicity testing to be completed in FY 1983 (U.S. DHHS 1983)

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Chemical Name

Benzene

CAS Number

71-43-2

Synonym

(6)Annulene, benzene (DOT), benzin, benzine, benzol, benzole, benzolene, bicarburet of hydrogen, carbon oil, coal naphtha, cyclohexatriene, mineral naphtha, motor benzol, NCI-C55276, nitration benzene, phene, phenyl hydride, pyrob, pyrobenzol, pyrobenzole

Chemical Classification

Aromatic hydrocarbon

Physical/Chemical Properties

Description:
Colorless, volatile, highly flammable liquid, with a distinct odor, like gasoline

Boiling point:
80.1° C

Melting point:
5.5° C

Molecular weight:
78.11

Chemical formula:
C_6H_6

Vapor pressure:
74.6 mm Hg at 20° C

Refractive index:
Highly refractive; n_D^{29} 1.5016

Solubility:
    Slightly soluble in H_2O (enough to be toxic to aquatic
    organisms); soluble in natural fats and fat soluble
    substances; miscible with acetone, alcohol, carbon
    disulfide, carbon tetrachloride, chloroform, ether,
    glacial acetic acid and oils

Octanol/water log partition coefficient:
    2.28

Photochemical reactivity:
    Not photoreactive

Density:
    0.8737 g/ml at 25° C

Vapor density:
    2.77 (air = 1)

Chemical reactivity:
    Activity toward O_2: slowly reacts with oxidizing materials
    Activity toward OH: half-life = 3 days
    Undergoes substitution, addition and cleavage of the ring

Environmental Fate

    Released into the atmosphere from both stationary and mobile sources,
    including from production, transportation, and storage of benzene

    Benzene occurs in ambient air from 1-100 ppm, in drinking water
    at approximately 10 ppb, and in subsurface water at 10 ppm

    Benzene is biodegradable

Sources of Emissions

    Production:
        An estimated 12 billion lb of isolated and non-isolated
        benzene (all grades) was produced in the United States in 1980

        From petroleum:
            Isolated from catalytic reformate
            Isolated from pyrolysis gasoline
            Direct from dealkylation of toluene
            Direct from disproportionation of toluene

From coal:
    Isolated from coke oven light oil
    Isolated from further separation techniques in coke
       oven operations
    Distillation of coal tar

Uses:
    Synthesis of other organic chemicals:
       Ethylbenzene (used in production of styrene)
       Cumene
       Cyclohexane
       Anilene
       Chlorobenzenes (for DDT and mothballs)
       Maleic anhydride
       Detergent alkylate

    Emissions of benzene from the production of other chemicals
    have been estimated as 44,000-56,000 tons. Concentrations in
    air near U.S. chemical manufacturing companies were reported
    in the range of 2 to 109 μg/m^3

    Solvent in chemical and drug industries

    Gasoline additive
        Emissions from gasoline production have been estimated as
        40,000-80,000 tons annually

    Benzene is used in the manufacture of styrene and phenol,
    dyes, benzene hexachloride insecticides, fumigants, paint
    removers, rubber cement, anti-knock gasoline, synthetic
    detergents

Storage and transport:
    Emissions from motor vehicle fueling and operation

    Gasoline service station emissions

    Bulk terminal (rail-tank-marine) loading/storage emissions

    Oil spills emissions

    Most of domestically shipped benzene goes by barge (79.6%),
    14.8% by rail, and 5.6% by truck

    Most pipeline shipment is restricted to benzene that is
    captively used by the producing plant

Disposition:
  Wastes containing benzene are mainly distillation residues
  from petrochemistry, spent catalysts, residues from coking
  processes and spent solvents from petrochemistry, the
  reprocessing of which is frequently too expensive

  Benzene is biodegradable. Diluted aqueous solutions,
  therefore, are drained into sewage treatment plants and
  decomposed there by anaerobic bacteria

  Solvent mixtures and sludges of higher concentration are
  burnt in special waste incinerators if a recovery process
  is uneconomical

  Tables D-29 through D-31 give benzene production, consumption,
  and emission data

Sampling and Analytical Methods

1. NIOSH method S311 for "Benzene"
    a. Adsorption on charcoal
    b. Desorption with carbon disulfide
    c. Gas chromatographic analyses

    Detection limits:
        13-51.8 ppm/2 1 sample

    Possible interferences:
        High-humidity causes inefficient trapping and
        decreases breakthrough volume

        Any compound present which has the same reten-
        tion time as benzene interferes with chemical
        identification

2. NIOSH method P&CAM 127, "Organic Solvents in Air"
    a. Adsorption on charcoal
    b. Desorption with carbon disulfide
    c. Gas chromatographic analyses

    Detection limits:
        0.01 mg/0.5 1 to 55 1 sample

TABLE D-29. ANNUAL EMISSIONS OF BENZENE
TO AIR FROM VARIOUS SOURCES

Source	Emission (thousand tons)
Component of gasoline*	40.0 - 80.0
Production of other chemicals	44.0 - 56.0
Indirect production of benzene[t]	23.0 - 79.0
Production of benzene from petroleum	1.8 - 7.3
Solvents and miscellaneous sources	1.5
Imports of benzene	0.013

* Production, storage, transport, vending and combustion

t Coke ovens, oil spills, nonferrous metals manufacturing, ore mining, wood processing, coal mining, and textile industry

Source: IARC 1982

TABLE D-30. BENZENE CONSUMPTION (1976)

Product use	Percent
Ethylbenzene	50.0
Cumene	16.6
Cyclohexane	14.9
Aniline	4.3
Chlorobenzenes	3.5
Maleic anhydride	2.7
Detergent alkylate	2.6
Miscellaneous applications	3.0
Exports	2.4

Source: Ochsner, Blackwood, and Zeagler 1979

Materials Damage

Fire hazard; explosion hazard

Permissible Exposure Limits

	OSHA	ACGIH
TWA	10 ppm 8-hr	10 ppm (30 mg/m^3)
Ceiling	25 ppm	25 ppm (75 mg/m^3)
PEAK	50 ppm/10 min.	

Human Toxicity

Acute toxicity:
Blood effects
Aplastic anemia
Narcotic action on CNS

Chronic toxicity:

Carcinogenicity--There is sufficient evidence that benzene is carcinogenic to humans. Several case reports as well as an epidemiological case control study establish a relationship between benzene exposure and leukemia

Mutagenicity--The evidence of mutagenicity in short-term tests is limited. Benzene has induced chromosomal abnormalities in occupationally exposed people

Other chronic effects:
Estrus cycle disorder
Liver, kidney and lung damage
Hormone alteration
Bone marrow hyperplasia

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Chemical Name

Benzyl chloride

CAS Number

100-44-7

Chemical Classification

Aromatic halogen

Synonyms

Alpha-tolylchloride; chloromethyl-benzene; alpha-chloromethyl-benzene; alpha-chlorotoluene

Physical/Chemical Properties

Description:
Benzyl chloride is a colorless to light yellow liquid, moderately volatile and a strong lacrimator

Boiling point:
179° C at 760 mm Hg

Melting point:
-39° C

Molecular weight:
126.6

Chemical formula:
$C_7 H_7 Cl$

Vapor pressure:
1.4 mm at 25° C
10 mm at 60.8° C
100 mm at 114.2° C

Refractive index:
$n_T^D = 1.5412$

Solubility:
Slightly soluble in water (49.3 mg/100 ml); soluble in lipids

Photochemical reactivity:
No photochemical degradation

Density:
1.026 at 18° C

Vapor density:
4.36 (air = 1)

Chemical reactivity:
Benzyl chloride undergoes Friedel-Crafts condensation reactions in the presence of such metals as iron, copper, zinc, aluminum, magnesium and tin. The compound hydrolyzes slowly in boiling water. The reactions of benzyl chloride involve
a. the reaction of the side chain containing the halogen, and
b. the reaction of the aromatic ring

Environmental Fate

Benzyl chloride decomposes slowly in the presence of water. The half-life for the hydrolysis of benzyl chloride at pH7 25° C is 15 hours, at 60° C hydrolysis is 45 times faster

Sources of Emissions

Production:
There are currently three producers of benzyl chloride at four locations. An estimated 115 million lb was produced in 1978. Table D-32 lists the plant locations and the estimated production

TABLE D-32. BENZYL CHLORIDE PRODUCERS

Company	Location	1978 Capacity (10^6 lb/yr)	1978 Production (10^6 lb/yr)
Monsanto	Bridgeport, NJ	80	52.5
	Sauget, IL	80	52.5
Stauffer	Edison, NJ	12	8.0
UOP, Inc.	E. Rutherford, NJ	3	2.0
	Total	175	115.0

Source: Mannsville Chemical Products 1978

Total estimated emissions (including process, storage, and fugitive) were 59,000 lb/year in 1978

Uses:
    The major end uses for benzyl chloride are butyl benzyl phthalate (75%) benzyl alcohol (7%), quarternary ammonium compounds (10%), and miscellaneous uses (8%) (1978 data)

    Table D-33 lists benzyl chloride emissions from producers and users

Transportation/storage:
    Benzyl chloride is shipped in glass carboys, phenolic-lined steel or nickel drums, tank cars and tank trucks. The chemical has an effective storage life of 2 to 3 months at normal temperatures. The emission factor from storage and handling has been estimated as 0.000025 to 0.00040 lb lost for lb produced and used

Disposition:
    No data available

Sampling and Analytical Methods

Sampling method:
    A known volume of air is drawn through a charcoal tube to trap the organic vapors present

    NIOSH Manual of Analytical Methods: Method No. S115

Analytical method:
    The sample is desorbed with carbon disulfide and the desorbed sample is injected into a gas chromatograph for analysis

    NIOSH Manual of Analytical Methods: Method No. S115

Detection limits:
    For a 10 1 sample (25° C 744 mm Hg), the detection range is 2-8 mg/m^3

Possible interferences:
1. High humidity
2. Compounds with the same column time retention will interfere with analysis

Permissible Exposure Limits

1 ppm (5 mg/m^3) OSHA standard

Human Toxicity

Chronic toxicity:

Carcinogenicity--There are no case reports or epidemiologic studies available in humans; however, benzyl chloride is carcinogenic in experimental rats. There is a long-term animal bioassay on test in FY83 by the National Toxicology Program

Mutagenicity--Benzyl chloride was weakly mutagenic to Salmonella typhimuiium (1975). Further microbial testing is on test for mutagenesis and genetic toxicity in FY83 by the National Toxicology Program

Other chronic toxicity:
Air concentrations of 32 ppm were reported to cause severe irritation of the eyes and respiratory tract of humans

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Chemical Name

Beryllium

CAS Number

7440-41-7

Chemical Classification

Chemical element, rare metal

Synonyms

Beryllium-9, glucinium, glucinum

Physical/Chemical Properties

Description:
Hard, noncorrosible grey metal of alkaline earth family:
lightest structural metal known. Beryllium is available
as powder, beads, electrolytic flakes, ingot, strip,
sheet, plate, foil, wire, rod, bar, tube, castings, and
fabricated parts

Boiling point:
2970° C

Melting point:
1284-1300° C

Atomic weight:
9.01

Chemical formula:
Be

Solubility:
Soluble in acids or alkalis

Atmospheric reactivity:
Two radioactive isotopes of Beryllium, Be^7 and Be^{10},
are formed in the upper atmosphere as a result of intense
cosmic-ray activity

Density:
    1.85 g/cm^3 (20° C)

Chemical reactivity:
    Reacts with hot water, alkali, and dilute acids;
    oxidation resistant; good transparency to X-rays; high
    heat capacity and thermal conductivity

Sources of Emission

Production:
    From beryl ore or from bertrandite ore: In recovering
    the metal from the usual ores (beryl and bertrandite),
    the sulfate process and the fluoride process produce
    beryllium oxide or hydroxide. This step is followed
    either by a thermal reduction or an electrolytic process.
    Thermal reduction involves the magnesium reduction of a
    halide, generally beryllium fluoride. The electrolytic
    process requires conversion to the chloride for the
    fused-salt bath and produces Be of higher purity.
    Approximately 74,000 lb of beryllium were produced in
    1977

Uses:
To form alloys with copper, nickel, and aluminum with
emissions of approximately 55,000 lb/year

In manufacture of ceramics and vitreous enamel

To make refractory crucibles as moderator and reflecting
material in nuclear reactors

To make gas mantles

As a window material for X-ray tubes

To produce a heat sink material in low-weight, high
performance aircraft brakes, and to make mirror compo-
nents of satellite optical systems

To make electrical components

Storage and transport:
    Usually stable during transport. Shipped in steel and
    fiber drums. Should be stored in dry place away from

acids, caustics, and chlorinated hydrocarbons. Kept separate from oxidizing materials

Disposition:
Emission losses at production sites are kept down by reusing beryllium occurring in production and processing (powder, chips, beryllium compounds)

Emission dusts can be controlled by use of filters and scrubbers at production and processing sites

Liquid or solid waste with too low a beryllium concentration to warrant recovery is disposed of in special dumps, but prior to disposal, the beryllium compound involved must be converted to the relatively inert oxide

Beryllium emissions occur during the combustion of fossil fuels which represents the major source of non-occupational exposure

Some sources of beryllium emissions are given in Tables D-34 through D-38

Sampling and Analytical Methods

1. NIOSH method P & CAM 121 for "Beryllium in Air" for use on air, settled dust, ore, and swipe samples

    a. Air samples can be collected by using a cellulose membrane filter, an electrostatic precipitator, or a chemically clean impinger containing 10% HNO_3 solution
        Settled dust and ore samples can be collected directly in chemically clean jars
        Swipe samples should be collected on Whatman filter paper
    b. Air samples are ashed with nitric acid, treated with 1:1 hydrochloric acid, and dissolved in a weak hydrochloric acid solution
        Ore and settled dust samples are ground in a mill to pass a U.S. Standard 200-mesh sieve
            -dust samples are ashed with nitric acid
            -ore samples are fused without ashing
    c. The samples are analyzed by atomic absorption spectrophotometry

    Detection limits:
        0.03-8.0 ug/ml

TABLE D-34. SOURCES OF BERYLLIUM EMISSIONS

Source
Mica, feldspar mining
Gray iron foundry   Cupola
Ceramic coatings
Beryllium alloys and compounds
Beryllium fabrication

Power plant boilers
    Pulverized coal
    Stoker coal
    Cyclone coal
    All oil

Industrial boilers
    Pulverized coal
    Stoker coal
    Cyclone coal
    All oil

Residential/commercial boilers
    Coal
    Oil

Source: Sittig 1975

198

Table D-35.   SOURCES OF BERYLLIUM FROM INDUSTRIAL AND SOLID
WASTE INCINERATION EMISSIONS

Source
Mining
Production of beryllium metal and its compounds

Cement plants
   Dry process
      Feed to raw mill

Wet process   Kiln
Clinker cooker
Clinker cooler
Processing or uses of beryllium and its compounds Beryllium alloys (stamped and drawn) Beryllium alloys (molding) Uncontrolled
After a baghouse
Ceramics Rocket propellants Beryllium metal fabrication

TABLE D-36. SOURCES OF BERYLLIUM EMISSIONS
FROM FUEL COMBUSTION, COAL

Source

Power plants
   Kansas
   South Carolina
   Illinois
   Michigan

Coal beds
   Maryland
   Ohio
   Pennsylvania
   Alabama
   Georgia
   Kentucky-east
   Kentucky-west
   Tennessee
   Virginia
   West Virginia
   Illinois
   Indiana
   Arkansas
   Iowa
   Missouri
   Oklahoma
   Montana
   North Dakota
   Wyoming
   Colorado
   Utah

Source: Sittig 1975

TABLE D-37. SOURCES OF BERYLLIUM EMISSIONS
FROM FUEL COMBUSTION, OIL

Source
Residual oil
Power plant, Connecticut
Residual No. 6

Source: Sittig 1975.

TABLE D-38. SOURCES OF BERYLLIUM EMISSIONS
FROM WASTE INCINERATION

Source
Sewage sludge incinerator Multiple hearth, after wet scrubber Fluidized bed, after wet scrubber
Municipal incinerator, uncontrolled
Municipal incinerator, after electrostatic precipitator

Source: Sittig 1975

Possible Interferences:
High concentrations of aluminum, silicon, and magnesium
depress the sensitivity of beryllium determination

2. NIOSH method P & CAM 173 for "General Procedure for Metals"
Same as method P & CAM 121 above

3. NIOSH method P & CAM 288 for "Beryllium and Beryllium Compounds
(as Be)"
a. filter collection
b. ashing of samples with nitric acid and sulfuric
acids; sample is solubilized in 3% sulfuric
acid with 2% sodium sulfate added
c. graphite furnace atomic absorption analyses

Detection limits:
0.5-10.0 µg/m^3

Possible interferences:
Calcium's effect is masked by 3% sulfuric acid
Sodium, potassium, and ammonium enhance the
absorbance of beryllium
Perchloric, phosphoric, and hydrofluoric acids
produce interferring non-atomic peaks

4. NIOSH method P & CAM 351 for "Trace Elements"
a. filter collection
b. acid digestion
c. inductively coupled plasma atomic emission spectroscopy
(ICR-AES)

Detection limits:
5-2000 µg/m^3, in a 500 1 air sample

Possible interferences:
Changes in density and viscosity of different acids and
acid concentrations affect the sample uptake rate

Chemical interferences:
Molecular compound formation
Ionization effects
Solute volatilization effects

Spectral interferences

5. NIOSH method S 339 for "Beryllium and Beryllium Compounds (as Be)"
   a. filter collection
   b. acid digestion
   c. flameless atomic absorption

   Detection limits:
      2.68-11.84 μg/m^3

   Possible interferences:
      None known

6. Tentative Method of Analysis for Beryllium Content of Atmospheric Particulate Matter
   a. cellulose, glass fiber, or membrane filter collection
   b. ash sample
   c. measure fluorescence of an aqueous beryllium solution with ultra violet light in the presence of morin

   Detection limits:
      0.01-1.0 μg Be/10 ml aqueous beryllium solution

   Possible interferences:
      Presence of zinc may interfere slightly

7. Analytical Methods for Beryllium and Beryllium Compounds:
   See Table D-39

Permissible Exposure Limits:

	OSHA	ACGIH
TWA	2 μg/m^3	2.0 μg/m^3 (0.002 ppm)
Ceiling	5 μg/m^3	
Peak	25 μg/m^3/30 min	

Human Toxicity:

Acute Toxicity:
   Inhalation of beryllium vapor causes acute "metal-fume fever" (foundryman's fever), which can be the preliminary stage of beryllium pneumonia

   Inhalation of beryllium dust can also cause pneumonia

   Beryllium slivers or dusts that penetrate the skin can produce poorly healing sores

Chronic Toxicity:

Carcinogenesis--Suspected human carcinogen. There is suf-
ficient evidence of carcinogenicity of some beryllium compounds
in experimental animals

Other Chronic Toxicity:
On test in FY 83 for biochemical/cellular/tissue effects,
for pulmonary toxicity, and for acute/chronic toxicity (U.S.
DHHS 1983)

Industrially used beryllium metal and its compounds cause
chronic respiratory disease (beryllium disease or
berylliosis)

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Chemical Name

Cadmium

CAS Number

7440-43-9

Chemical Classification

Elemental metal

Synonyms

C.I. 77180

Physical/Chemical Properties

Description:
Soft blue-white malleable metal or grey powder

Boiling point:
767° C

Melting point:
321° C

Atomic weight:
112.4

Atomic formula:
Cd

Vapor pressure:
0 at 20° C

Density:
3.65

Refractive index:
1.13

Solubility:
Insoluble in water; soluble in dilute acids

Photochemical reactivity:
    Retention time in the atmosphere is dependent on parti-
    cle size and meteorological parameters. Cadmium found
    in the air is usually in particulate form as the oxide,
    chloride or sulfate

Environmental Fate

About 85 percent of cadmium aerosols were found to be soluble.
Cadmium which is emitted to the air is ultimately deposited in the
soil and water. The half-life of cadmium in humans has been
calculated to be as long as 38 years

Sources of Emission

The primary metals industry (mining and processing), waste
disposal by incinerator, fertilizer processing, and the
burning of fossil fuels are the principal man-made stationary
sources of cadmium emissions to air. Cadmium vaporization
occurs at fairly low temperatures, approximately 767° to 907° C,
and therefore is readily emitted by processes such as ore
roasting, pyrosmelting, steel scrap melting, incineration of
wastes and burning of fossil fuels. Total estimated emis-
sions of cadmium from stationary sources are 3,260,000 lb/
year and mobile sources add approximately 70,000 lb/year
for a total of 3,326,000 lb/year. Some estimates of cadmium
emissions by source are presented in Table D-40

Production:
    The 1980 domestic production of cadmium and eight high
    volume cadmium compounds was about 17 million lb and
    2 million lb were imported

Uses:
    Cadmium and certain cadmium compounds are widely used
    commercially in electroplating, alloys, solders, plas-
    tic stabilizers, batteries, fungicides, and in phosphors
    and pigments for television tubes, inks, artists'
    colors, glass, ceramics, textiles, paper, and fertil-
    izers. Emission sources for cadmium from consumptive
    uses, industrial sources, and processes are presented
    in Tables D-41 to D-43

TABLE D-41. EMISSION FACTORS FOR CONSUMPTIVE USES OF CADMIUM

Source[a]	Emission factors
Rubber tire wear	$0.003 \text{ kg}/10^6 \text{ km}$ ($0.01 \text{ lb}/10^6$ vehicle miles)
Fungicides	$0.02 \text{ kg}/10^3$ liters ($0.05 \text{ lb}/10^3$ gal.) of spray
Superphosphate fertilizers	$0.0001 \text{ kg}/10^3 \text{kg}$ (0.0002 lb/ton) of fertilizer
Motor oil consumption (in vehicle)	$0.0006 \text{ kg}/10^6 \text{km}$ ($0.002 \text{ lb}/10^6$ vehicle miles)
Cigarettes	$16.0 \mu g/20$ cigarettes

[a] All sources are uncontrolled.

Source: Sittig 1975

TABLE D-43. EMISSION FACTORS FOR PROCESSES
INVOLVING CADMIUM

Source [a]	Emission factor, kg/10³kg (lb/ton) of cadmium charged
Pigments	8 (15)
Plastic stabilizers	3 (6)
Alloys and solders	5 (10)
Batteries (Ni-Cd)	1 (2)
Miscellaneous (x-ray screens, cathode ray tubes, nuclear reactor components, etc.)	1 (2)

[a] Emission are uncontrolled unless otherwise specified.

Source: Sittig 1975

Disposition:
Emission factors for cadmium from waste incineration
have been estimated in the range of 0.003 lb/10³ tons
to 0.8 lb/10³ tons depending on source. These emis-
sion factors are presented in Table D-44

Sampling and Analytical Methods

Cadmium dust--NIOSH Manual of Analytical Methods; Method
number S 312

Sampling method:
Sample containing filters are wet-ashed with nitric
acid and the sample is solubilized in hydrochloric acid

Analytical method:
The sample solution is aspirated into an atomic absorp-
tion spectrophotometer. The absorbance is proportional
to the cadmium concentration

Detection limits:
This method was validated in the range of 0.12 to
0.98 mg/m³ using a 2.5 l sample

Possible interferences:
    There are no known spectral line interferences for this
    assay

Cadmium fume--NIOSH Manual of Analytical Methods; Method number
    S313

    The method is simple and specific for cadmium, but will
    not distinguish between cadmium dust and cadmium fume

Permissible Exposure Limits

OSHA Standard
    0.1 mg/m^3 8-hr TWA (fumes)
    0.3 mg/m^3 ceiling (fumes)
    0.2 mg/m^3 8-hr TWA (dust)
    0.6 mg/m^3 ceiling (dust)

Human Toxicity

Acute Toxicity:
    About 1 mg/m^3 of cadmium inhaled over an 8-hour period gives
    rise to clinical symptoms such as pulmonary congestion and
    edema; an air level of cadmium of 5 mg/m^3 inhaled over the
    same period can be lethal

Chronic Toxicity:

    Carcinogenicity--The evidence of carcinogenicity in humans is
    limited; studies have suggested that occupational exposure to
    cadmium (possibly the oxide) increases the risk of prostate,
    respiratory, and genitourinary cancers in humans. The evidence
    for the carcinogenicity of cadmium and certain cadmium
    compounds in experimental animals is sufficient

    Mutagenicity--There is conflicting evidence with regard to the
    production of chromosomal aberrations in humans exposed
    to cadmium

    Teratogenicity--There is no evidence that cadmium is teratogenic
    in humans. Teratogenic effects have been demonstrated in
    animals using very high doses

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Chemical Name

Carbon Tetrachloride

CAS Number

56-23-5

Chemical Classification

Halogenated hydrocarbon

Synonyms

Benzinoform; carbon chloride; carbona; flukoids; freon 10; halon 104; methane tetrachloride; methane, tetrachloro-necatorina; perchloromethane; tetrachlorocarbon; tetrachloromethane; tetrafinol; tetraform; tetrasol

Physical/Chemical Properties

Description:
    Clear, colorless heavy liquid

Boiling point:
    76.75° C

Melting point:
    -22.8° C

Molecular weight:
    153.8

Chemical formula:
    CCl_4

Vapor pressure:
    91 mm Hg 20° C
    113 mm Hg 25° C

Vapor density:
    5.32 (air = 1)

Refractive index:
    1.4607 20° C

Solubility:
  Miscible in organic liquids. Solubility in water
  0.08 g/100 ml water at 25° C.

Log partition coefficient (octanol/water):
  2.64

Photochemical reactivity:
  CCl_4 is stable in the troposphere and there is appar-
  ently an absence of physical or biological removal mechanisms.
  Therefore, CCl_4 would be expected to be a precursor of
  stratospheric ozone-destroying chlorinations

Chemical reactivity:
  Chemically not reactive; not easily hydrolyzed

Environmental Fate

  CCl_4 is stable in air and water and tends to bioaccumulate.
  It has a half life of about 10 years

Sources of Emissions

Production:
  U.S. production of CCl_4 was estimated as over 1 billion
  lb in 1974 and dropped to an estimated 717 million lb
  in 1981
  Production emissions for 1978 are presented in Table D-45

Uses:
  The major end-use for CCl_4 is in the production of
  fluorocarbon gases. The remaining CCl_4 production is
  used in solvent applications as an oil, wax and fat
  extractant; in rubber cement; in polishes, paints and
  lacquers; in printing inks and stains; and in pesticide
  manufacturing. Estimated end use consumption; nation-
  wide emissions and point sources are presented in
  Tables D-46 and D-47 and Figure D-3

Storage:
  Storage emission factors were reported from two site
  visits as 0.000442 and 0.00374 lb per lb used

Disposition:
 Emissions data from disposition were not available.
 Most large-scale consumers recover impure solvents by
 distillation. Residues from recovery operations are
 waste dumped or burnt in special waste incinerators

Sampling and Analytical Methods

NIOSH Manual of Analytical Methods--Method Number S 314

Sampling method:
 A known volume of air is drawn through a charcoal tube
 to trap the organic vapors present

Analysis method:
 An aliquot of the sample that has been desorbed with
 carbon disulfide is injected into a gas chromatograph

Detection limits:
 The working range of this method is 16-480 mg/m^3 for
 a 15 l sample size

Possible interferences:
 1. High humidity

 2. Compounds present in the sample with the same
    column retention size

Materials Damage

Reacts sometimes exposively with aluminum and its alloys

Permissible Exposure Limits

OSHA Standard
 10 ppm 8-hr TWA
 25 ppm ceiling
 200 ppm maximum peak for 5 min in any 4-hr period

Human Toxicity

Acute Toxicity:
 Humans exposed to 14,000 ppm for 50 s were rendered unconscious.
 CCl$_4$ can produce coma and death from respiratory arrest or
 circulatory collapse

Chronic Toxicity:

Carcinogenesis--There are suggestive case reports of liver cancer in humans. There is sufficient evidence that CCl_4 is carcinogenic in experimental animals

Mutagenicity--There is no evidence that CCl_4 is mutagenic

Teratogenicity--CCl_4 is fetotoxic in experimental animals. There were no data available in humans. Biochemical, cellular tissue effects, and systemic organ toxicity are on study in FY83 (U.S. DHHS 1983)

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Carbon <u>Tetrachloride.</u>

U.S. Environmental Protection Agency. <u>Chemical Hazard Information Profile.</u>
Carbon <u>Tetrachloride.</u>

Chemical Name

Chlorobenzene

CAS Number

108-90-7

Chemical Classification

Halogenated cyclic hydrocarbon

Synonyms

Monochlorobenzene, phenyl chloride, chlorobenzol, MCB, benzene chloride

Physical/Chemical Properties

Description:
    Colorless liquid, very refractive, highly volatile

Boiling point:
    131.7° C

Melting point:
    -45.6° C

Molecular weight:
    112.56

Chemical formula:
    C_6H_5Cl

Vapor pressure:
    12.14 mm at 25° C

Density:
    1.1058 at 20° C (rel. water at 4° C)

Vapor density:
    3.88 (air = 1)

Refractive index:
    1.5216 (25° C) highly refractive

Solubility:
    Insoluble in water

Log partition coefficient (octanol/H_2O):
2.84

Photochemical reactivity:
No photochemical degradation

Chemical reactivity:
At ordinary temperatures and pressure, chlorobenzene is unaffected by the presence of air, moisture or light. At moderate temperatures, chlorobenzene is also nonreactive

Sources of Emissions

Production/processing:
Commercially important chlorobenzenes are mono-chloro-benzene and the two dichlorobenzenes, ortho and para. In 1978 an estimated 355 million lb of monochlorobenzene was produced, 59 million lb of ortho-dichlorobenzene and 55 million lb of para-dichlorobenzene. Tables D-48 through D-50 present the producers, location, and estimated production. Tables D-51 through D-53 present the estimated emissions at these sites from process, storage and fugitive (emissions from plant leaks)

Uses:
The end-use distribution of chlorobenzenes is presented in Table D-54

Estimated emissions from end-uses are presented in Table D-55

Disposition:
Chlorobenzenes should be disposed of by atomizing in a combustion chamber equipped with appropriate effluent gas cleaning devices. Chlorobenzenes have been detected at hazardous waste sites. Emissions data from disposition were not located

Sampling and Analytical Methods

NIOSH Manual of Analytical Methods: Method number S133

Sampling methods (monochlorobenzene):
A known volume of air is drawn through a charcoal tube to trap the organic vapors present

Analysis:
Desorb sample with carbon disulfide and analyze by gas chromography

TABLE D-48. MONOCHLOROBENZENE PRODUCERS

Source	Location	1978 Estimated Production (10^6 lb/yr)	1978 Estimated Capacity (10^6 lb/yr)
Dow	Midland, MI	101	220
ICC	Niagara Falls, NY	5	10
Monsanto	Sauget, IL	69	150
Montrose	Henderson, NV	32	70
PPG	New Martinsville, WV	79	172
Standard Chlorine	Delaware City, DE	69	150
Total		355	772

Source: Systems Applications, Inc. 1980

TABLE D-49. o-DICHLOROBENZENE PRODUCERS

Source	Location	1978 Estimated Production (10^6 lb/yr)	1978 Estimated Capacity (10^6 lb/yr)
Dow	Midland, MI	12	30
Monsanto	Sauget, IL	6	16
PPG	New Martinsville, WV	15	38
Standard Chlorine	Delaware City, DE	19	50
Specialty Organics	Irwindale, CA	1	2
Montrose	Henderson, NV	3	7
ICC	Niagara Falls, NY	3	8
Total		59	151

Source: Systems Applications, Inc. 1980

TABLE D-50. p-DICHLOROBENZENE PRODUCERS

Source	Location	1978 Estimated Production (10^6 lb/yr)	1978 Estimated Capacity (10^6 lb/yr)
Dow	Midland, MI	9	30
Monsanto	Sauget, IL	4	12
PPG	New Martinsville, WV	13	40
Standard Chlorine	Delaware City, DE	24	75
Specialty Organics	Irwindale, CA	1	2
Montrose	Henderson, NV	2	7
ICC	Niagara Falls, NY	2	8
Total		55	174

Source: Systems Applications, Inc. 1980

TABLE D-54.   CHLOROBENZENES END-USE DISTRIBUTION 1978

Source	Usage (million lb/yr)	Usage (%)
Monochlorobenzene	355	100
Pesticide/degreasing solvents	174	49
Nitrochlorobenzene	107	30
DDT	25	7
Diphenyl oxide	28	8
Miscellaneous, others	21	6
o-Dichlorobenzene	59	100
3,4 dichloroaniline	38	65
Toluene diisocyanate solvent	9	15
Miscellaneous solvents (paint removers, engine cleaners, etc.)	6	10
Dye manufacturing	3	5
Pesticide intermediate	3	5
p-Dichlorobenzene	55	100
Space deodorant	27.5	50
Moth control	22	40
Pesticide intermediate	5.5	10

Source: Systems Applications, Inc. 1980

TABLE D-55.   1978 NATIONWIDE EMISSIONS OF CHLOROBENZENES

Source	Nationwide Emissions (lb/yr)
Monochlorobenzene	
Production	1,136,000
Pesticide/degreasing solvents	174,000,000
Nitrochlorobenzene	171,200
DDT	12,500
Diphenyl oxide	28,500
Miscellaneous, other	27,930
Sub-total	175,376,130
o-Dichlorobenzene	
Production	209,450
3,4-Dichloroaniline	57,000
Toluene diisocynnate solvent	9,000,000
Miscellaneous solvents	6,000,000
Dye manufacturing	1,500
Pesticide intermediate	1,500
Sub-total	15,269,450
p-Dichlorobenzene	
Production	398,200
Space deodorant	27,500,000
Moth control	22,000,000
Pesticide intermediate	2,750
Sub-total	49,900,950
Total - all chlorobenzenes	240,546,530

Source: Systems Applications, Inc. 1980

232

Detection limits:
This method has been validated over the range of
183-736 mg/m^3 (25° C 761 mm Hg) using a 10 1 sample

Possible interferences:
1. High humidity
2. Compounds present with the same column retention
   time.

Materials Damage

Liquid chlorobenzene may attack some forms of plastics,
rubber, and coatings

Permissible Exposure Limit

OSHA Standard
75 ppm (345 mg/m^3)

The immediately dangerous to life or health (IDLH) con-
centration is 2400 ppm

Human Toxicity

Chronic Toxicity:

Carcinogenicity--No adequate animal or human epidemiological
studies are available for evaluation. However, a long-term
animal carcinogenesis bioassay is being completed in FY83 by
the National Toxicology Program for monochlorobenzene; a
long-term animal carcinogenesis bioassay for p-dichlorobenzene
is being initiated in FY83 (U.S. DHHS 1983)

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Systems Applications, Inc. 1980. <u>Human Exposure to Atmospheric Concentrations of Selected Chemicals, Vol. 1</u>. EPA/OAQPS PB81-193252.

Chemical Name

Chloroform

CAS Number

67-66-3

Chemical Classification

Halogenated unsaturated hydrocarbon, halogenated methane, chlorinated aliphetic hydrocarbon, halocarbon

Synonyms

Chloroform (DOT), chloroform (BCI), formyl trichloride, freon 20, methane trichloride, methane, trichloromethenyl chloride, methenyl trichloride, methyl trichloride, NCI-C02686, R 20, R 20 (refrigerant), R 20 (van), trichloroform, trichloromethane

Physical/Chemical Properties

Description:
Heavy, water-white, volatile liquid with a pleasant, non-irritant odor; nonflammable

Boiling point:
61.25° C

Melting point:
-63.5° C

Molecular weight:
119.39

Chemical formula:
$CHCl_3$

Vapor pressure:
200 mm Hg at 25.9° C; 246 mm Hg at 30° C

Refractive index:
1.4467 at 20° C

Solubility:
Miscible with principal organic solvents; slightly
soluble in water (8.0 g/l)

Octanol/water log partition coefficient:
1.17

Photochemical reactivity:
Highly reactive in the troposphere and will undergo
thermal tropospheric reactions
When exposed to air and light, chloroform breaks down
to phosgene, HCl, and chlorine
half-life = <1 year (OH) atmospheric loss
0.9% loss/day (12 sun hrs)

Vapor density:
4.12

Chemical reactivity:
Reacts with strong caustics, chemically active metals
(aluminum, magnesium powder, sodium, potassium)

Environmental Fate

Degrades easily in the atmosphere to phosgene and chlorine
monoxide with a half life of ~2-3 months
Found less frequently than other chlorinated hydrocarbons.
Chloroform is an ubiquitous material in the atmosphere at
trace amounts, due to industrial emissions, release from end
use applications and to formation due to reaction of chlorine
and methanol in the atmosphere

Sources of Emissions

Production:
176 million lb in 1977
chlorination of methane
hydrochlorination of methanol or methyl
chloride chlorination
reduction of carbon tetrachloride

Uses:
    In production of chlorodifluoromethane

    To produce fluorocarbon 22, a refrigerant and aerosol pro-
    pellant, to make fluorocarbon resins (used 107,250 tons in
    1975 or ~80% of chloroform production)

    As an industrial solvent; to make pharmaceuticals or pesti-
    cides (leads to a population exposed to ~300,000 lb/year of
    chloroform)

    As a laboratory solvent

    Heat transfer medium

    As a fire extinguisher

Storage and Transport:
    Should be stored in sealed containers in a cool place;
    glass containers should be dark green or amber

    Technical grade chloroform can be stored in lead lined
    or mild steel containers of all welded construction

    Technical grade is shipped in galvanized steel drums,
    tank trucks, or tank cars

Dispostion:
    Production losses to air

    Emissions from bleaching of paper pulp using chlorine

    Decomposition of perchloroethylene may be a source of
    chloroform in the atmosphere

    Occurs in leachate of sanitary landfills

Tables D-56 through D-58 and Figure D-4 present chloroform produc-
tion, end use, and emissions data

Sampling and Analytical Methods

    1. NIOSH method S 351 for chloroform
        a. adsorption on charcoal
        b. desorption with carbon disulfide
        c. gas chromatography

        Detection limits:
            0.10 mg/0.5 to 13 1 sample

TABLE D-56. PRODUCTION OF CHLOROFORM

Source	Location	1978 Estimated Production (10^6 lb/yr)	Process
Allied Chemical Corp.	Moundsville, WV	19	A,B
Diamond Shamrock	Belle, WV	26	A
Dow Chemical	Freeport, TX	64	B
	Plaquemine, LA	64	A
Stauffer Chemical Co.	Louisville, KY	49	A
Vulcan Materials Co.	Geismar, LA	38	A
	Wichita, KS	70	A,B
Total		330	

(A) - Methanol hydrochlorination process or methyl chloride chlorination process.
(B) - Methane chlorination process.

Source: Systems Applications, Inc. 1980

TABLE D-57. 1978 CHLOROFORM CONSUMPTION BY END-USE

End Use	Percent of Total Consumption	End Use Consumption (M lb)
Chlorodifluoromethane (F-22) refrigerants	61	201.3
Chlorodifluoromethane (F-22) resin intermediates	25	82.5
Export	7	23.1
Solvent/miscellaneous	7	23.1
Total	100	330.0

Source: Systems Applications, Inc. 1980

Possible interferences:
High humidity (decreases breakthrough volume)
Presence of other solvents
Presence of other compounds with same retention
time as chloroform

2. <u>Method B</u> (Appendix A): C_2-C_{18} hydrocarbons and other
nonpolar organics with a boiling point -100 to 175° C

Whole air collection in canister
Cryogenic concentration
Gas chromatography/flame ionization detection

Detection limits:
0.1 ppb per 100 ml sample

Possible interferences:
Reactive and water soluble compounds are not
readily analyzed

3. <u>Method C</u> (Appendix A): C_6-C_{12} hydrocarbons and other
nonpolar organics with boiling point between 60 and
200° C

Adsorption on tenax
Thermal desorption
Gas chromatography/mass spectrometry analysis

Detection limits:
1-200 ppt for a 20 1 sample

Possible interferences:
Blank levels usually limit sensitivity
Artifacts due to reactive components (O_3, NO_x)
can be a problem
Sample can be analyzed only once

4. <u>Method D</u> (Appendix A): C_6-C_{12} hydrocarbons and other
nonpolar organics with boiling point of 60-200° C

Adsorption in Tenax
Thermal desorption into canisters
Gas chromatography/flame ionization detection, or gas
chromatography/mass spectrometry analyses

Detection limits:
0.01-1 ppb for a 20 1 sample

Possible interferences:
Blanks and artifact problems as in method C, above

Materials Damage

Liquid chloroform will attack some forms of plastics, rubber, and coatings

Permissible Exposure Limits

	OSHA	NIOSH	ACGIH
TLV	50 ppm (240 mg/m^3)		10 ppm (50 mg/m^3)
Ceiling		2 ppm/1 hour	50 ppm (225 mg/m^3)

Human Toxicity

Acute Toxicity:
Chloroform vapor is a central nervous system depressant and is toxic to the liver and kidneys

Chronic Toxicity:

Carcinogenicity--There is sufficient evidence for the carcinogenicity of chloroform in experimental animals

Mutagenesis--Chloroform failed to produce mutagenetic changes in the Chinese hamster

Teratogenesis--Chloroform appears to be somewhat teratogenic and highly embryotoxic in animals

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Chemical Name

Chloroprene

CAS Number

126-99-8

Chemical Classification

Halogenated hydrocarbon

Synonyms

2-chloro-1,3-butadiene; chlorobutadiene; beta-chloroprene

Physical/Chemical Properties

Description:
Colorless volatile liquid with an ether-like odor

Boiling point:
58.9° C

Melting point:
-130° C

Molecular weight:
88.5

Chemical formula:
C_4H_5Cl

Vapor pressure:
179 mm Hg at 20° C
215.4 mm Hg at 25° C

Vapor density:
3 (air = 1)

Refractive index:
n_D^{20} 1.4583

Solubility:
Partially soluble in water; soluble in most organic
solvents

Photochemical reactivity:
    Resistant to sunlight

Chemical reactivity:
    Reacts with oxygen to form peroxides. Enters into
    addition reactions with halogens. Forms high
    molecular weight elastomeric polymers.

Sources of Emissions

Production/processing:
    EPA reports domestic production of chloroprene at
    1 billion lb by four producers in one region
    (public record, TSCA Inventory). EPA/OAQPS has
    estimated that within 20 km of manufacturing
    sites exposure to chloroprene is at median
    concentrations of <0.05 to >0.025 $\mu g/m^3$

Uses:
    Most of the chloroprene is used in the production
    of polychloroprene elastomers. Airborne concen-
    trations at a chloroprene polymerization plant
    ranged from 14-1400 ppm in the make-up area,
    130-6800 ppm in the reactor area, and 110-250 ppm
    in the latex area

Storage and transport:
    Chloroprene has to be stored and transported
    cooled to -10° C under an inert gas. Emissions
    are probably minimal

Disposition:
    Due to high reactivity and volatility chloroprene
    and chloroprene-containing wastes cannot be dumped.
    Wastes have to be destroyed in special waste
    incinerators

Sampling and Analytical Methods

NIOSH Manual of Analytical Methods. Method number S 112

Sampling method:
    A known volume of air is drawn through a charcoal
    tube containing activated coconut charcoal to
    trap chloroprene vapors

Analytical method:
  Chloroprene is desorbed from the charcoal with
  carbon disulfide and the sample is analyzed by
  GC

Detection limits:
  This method was validated over the range of
  44 to 174 mg/m^3 at 21° C 760 mm Hg using a
  3 1 sample

Possible interferences:
  Any compound having the same column retention
  time under the same analytical operating
  conditions could cause interference of chemical
  identity

Permissible Exposure Limits

OSHA Standard:
  25 ppm (90 mg/m^3)

NIOSH recommendation:
  1 ppm/15 min ceiling

Human Toxicity

Acute toxicity:
  High concentrations (no exact data) lead to
  collapse and death from acute pulmonary edema

Chronic toxicity:

  Carcinogenicity--Inadequate evidence

  Mutagenicity--Epidemiological evidence consistent with experi-
  mental evidence that chloroprene is mutagenic in humans

Other chronic toxicity:
  Reproductive toxicity supported by epidemiological evidence

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Chemical Name

Chromium

CAS Number

7440-47-3

Synonym

Chrome

Chemical Classification

Elemental metal

Physical/Chemical Properties

Description:
Silver, blue-white, hard, brittle lustrous metal

Boiling point:
2672° C

Melting point:
1857 $\pm$20° C

Atomic weight:
51.9

Atomic formula:
Cr

Vapor pressure:
Essentially 0 at 210° C

Solubility:
Insoluble in water; some chromium salts are very soluble
in water

Density:
7.2 g/cm^3 at 28° C

Chemical reactivity:
        Not oxidized by air even in the presence of moisture;
        reacts with dilute hydrochloric and sulfuric acids;
        attacked by caustic alkalies and alkali carbonates

Environmental Fate

        Under environmental conditions, when oxygen is present,
        chromium exists as elemental, trivalent or hexavalent
        chromium

Source of Emissions

        Production/processing:
                Chromite ore consists of varying percentages of chromium,
                iron, aluminum and magnesium oxides. Current U.S. mine
                production is believed negligible. In 1978, 17,705 mil-
                lion lb of chromite ore were imported

                The 1980 domestic production of chromium and ten important
                chromium compounds was an estimated 750 million lb.
                Approximately 100 million lb were imported in 1980

        Uses:
                Chromium metal and metal alloys are used primarily in
                stainless, alloy and heat resisting steel. Other chromium
                compounds are used in chemical processing, refining, plat-
                ing and a number of specialty uses. Table D-59 presents
                sources and estimates of chromium emissions for 1970

        Disposition:
                The galvanizing and metal processing industries are a major
                source of chromate waste

                Chromium-containing sludges or residues cannot be disposed
                of in incinerators as the trivalent chromium is reoxidized
                to the toxic hexavalent chromium with heat. Emissions
                data from disposition were not available

Sampling and Analytical Methods

1. Total particulate chromium sampling method

   NIOSH Manual of Analytical Methods. Method number
   P&CAM 152

   Sampling:
   Atmospheric samples are obtained by drawing a measured
   volume of air through a 0.8 μm filter

   Analysis:
   The filter is wet-ashed and analyzed for chromium
   by atomic absorption spectroscopy

   Detection limit:
   The working range in air is from 0.1 mg/m^3 to
   0.4 mg/m^3 using a sample of 100 1 of air

   Possible interferences:
   A number of metallic elements may interfere with
   the atomic absorption analysis

2. Chromium, metal and insoluble compounds

   NIOSH Manual of Analytical Methods. Method number
   S352

   Sampling:
   A known volume of air is drawn through a cellulose
   ester membrane filter to collect the analyte

   Analysis:
   Samples are ashed to destroy the filter and other
   organic compounds in the sample, and the chromium
   metal and other insoluble chromium compounds are
   dissolved in nitric acid. The solution of sample
   is aspirated into the flame of an atomic absorption
   spectrophotometer for analysis

   Detection limits:
   A 90 1 sample has a working range of 0.05 to
   2.5 mg/m^3 at 26° C 761 mm Hg

   Possible interferences:
   1. Soluble chromium compounds
   2. Iron and nickel present in the sample

Permissible Exposure Limit

OSHA standard:
0.1 mg/m^3 ceiling (chromic acid and chromates);
0.5 mg/m^3 8-hr TWA (soluble chromic or chromous salts);
1 mg/m^3 8-hr TWA (metal and insoluble salts)

Human Toxicity

Chronic toxicity:

Carcinogenicity--There is sufficient evidence for the carcinogenicity of chromium and certain chromium compounds both in humans and experimental animals. There is sufficient evidence for increased incidence of lung cancer among workers in the chromate-producing industry, and possibly among chromium platers and alloy workers

Mutagenicity--An increased frequency of chromosomal aberrations has been observed in workers exposed to chromium (VI) compounds

Teratogenicity--Some teratogenic effects in animals have been reported with chromium (III) and chromium (VI) compounds using very high doses. No human data are available

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Chemical Name

2,3,7,8-Tetrachlorodibenzo-para-dioxin (TCDD)

CAS Number

1746-01-6

Chemical Classification

Polychlorinated dioxin. There are 75 chlorinated dibenzo-para-dioxins identified of which 2,3,7,8-TCDD is the most toxic

Synonyms

Dioxin, TCDBD, TCDD, 2,3,7,8-Tetrachlorodibenzodioxin; 2,3,7,8-Tetrachlorodibenzo-1,4-dioxin; 2,3,7,8-Tetrachlorodibenzo(b,3)(1,4)dioxin

Physical/Chemical Properties

Description:
Colorless needles

Melting point:
305°-306° C

Molecular weight:
322.96

Chemical formula:
$C_{12}H_4Cl_4O_2$

Solubility:

Solvent	Solubility, g/l
ortho-dichlorobenzene	1.4
chlorobenzene	0.72
benzene	0.57
chloroform	0.37
acetone	0.11
n-octanol	0.05
methanol	0.01
water	2×10^{-7}

Photochemical reactivity:
    In studies exposing nanogram quantities of TCDD to sunlight,
    50 percent degradation occurred in 5 to 6 hours. The chlori-
    nated dibenzo-para-dioxins when dissolved in methanol are
    easily degraded by strong sunlight

Chemical reactivity:
    The chlorinated dioxins are extremely stable and persistent
    compounds. TCDD is a very stable chemical that resists
    breakdown by other chemicals

Atmospheric reactivity:
    Some data indicate that the chemical can be photodegraded

Environmental fate

    Soil:
    TCDD has been reported as immobile in soil samples of varying
    textures. In a study conducted by the U.S. Air Force, levels
    up to 1.5 ug/kg were found in soil 10 to 12 years following
    aerial spraying of herbicides containing TCDD. The microbial
    degradation of TCDD is reported to be relatively rare in
    nature

Sources of Emissions

    Production:
    The chlorodibenzo-para-dioxins are not manufactured commercially

    Byproduct sources:
    TCDD forms as a hazardous byproduct during the preparation of
    2,4,5-trichlorophenol, a major intermediate in the manufacture
    of several herbicides, fungicides, and wood preservatives

Byproduct sources:
Estimated emission rates by specific plants (SAI 1980)

Company	Site	Type of production*	Emission rate* (mg/sec)
Dow	Midland, MI	1	0.003298
		2	0.018000
		3	0.042480
PBI-Gordon	Kansas City, KA	1	0.003298
Riverdale	Chicago Heights, IL	1	0.003298
Union Carbide	Ambler, PA	1	0.003298
Union Carbide	Fremont, CA	1	0.003298
Union Carbide	St. Joseph, MO	1	0.003298
Vertac	Jacksonville, FL	1	0.003298
		2	0.018000
Monsanto	Sauget, IL	3	0.042480
Reichhold	Tacoma, WA	3	0.042480
Vulcan	Wichita, KA	3	0.042480

* Estimated nationwide emissions (lb/yr) during 1978 are as follows (SAI 1980):
  Type 2 Trichlorophenol production   2.5
  Type 1 2,4,5-T production   1.6
  Type 3 Pentachlorophenol production 11.8
These were allocated equally among the sites over 8,760 hours

Contaminant sources:
The following materials are known to contain trace amounts of TCDD as an impurity:
1,3,4,5-tetrachlorobenzene
2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and its esters
hexachlorophene
pentachlorophenol
2,4,5-trichlorophenoxypropionic acid (silvex)
2,4-dichlorophenoxyacetic acid (2,4-D)
clophen
Agent Orange: 50:50 mixture of 2,4,5-T and 2,4-D
Locust bean gum (food stabilizer)

The following emissions are estimated to result from use of these materials in 1978 (SAI 1980):
2,4,5-T applications   6.5 lb
Pentachlorophenol as wood preservative   42.3 lb

Combustion sources:
Trace levels of dioxins (including TCDD) may be present in fly ash and flue gases from the following sources:

- Incinerated waste material containing grass clippings and wood previously treated with contaminated herbicides
- Particulate emisions from incinerators, powerhouse boiler stacks, and fireplaces
- Emissions from the combustion of chlorinated organic chemicals such as polychlorinated benzenes, polychlorinated phenols, and polyvinyl chloride plastics
- Emissions from fires in transformers containing chlorinated benzenes and polychlorinated biphenyls
- Emissions from the combustion of gasoline, diesel fuel, and cigarettes resulting in air levels of 0.001 to 1100 ppb

The estimated emissions of TCDD during 1978 due to combustion processes are as follows (SAI 1980):

Source	Particulate Emissions (tons/yr)	Total Emissions (lb/yr)*
Open burning	2,161,142	8.6
Agriculture	1,433,712	5.7
Forest fires	526,843	2.1
Refuse open burning	212,211	0.8
Conical burners	193,500	0.8
Coal burning--all sources	108,952	0.4
Oil burning--all sources	72,389	0.3
Incineration, municipal domestic	30,123	0.1
Total		18.8

* Based on a TCDD emission concentration in particulate matter of 2 ppb

Uses:
TCDD is not used commercially. This compound has been tested for use in flameproofing polymers, and against insects and wood-destroying fungi, but these uses are not known to have been exploited commercially

TCDD has no reported use other than as a test chemical in basic research

Storage:
    Not applicable

Transportation:
    Not applicable

Disposition:
    Abandoned dump sites which contain wastes from herbicide
    manufacturing, particularly 2,4,5-TCP, are major sources of
    TCDD

    Under the Resource Conservation and Recovery Act (RCRA), TCDD
    has been designated by the EPA as a hazardous constituent of
    waste, which subjects the chemical to special handling and
    recordkeeping requirements. Under the Toxic Substances
    Control Act, Section 6, the EPA restricts the removal of TCDD
    in wastes except with EPA approval in compliance with RCRA
    requirements

Sampling and Analytical Methods

1.   Commercial chlorophenols analysis for chlorodibenzo-para-dioxins
     a.   Analysis on an aluminum oxide column
     b.   Detection by gas chromatography with electron capture
     c.   Confirmation by mass spectroscopy

     Detection limits:
         20 µg/kg

     Possible interferences:
         Presence of other compounds with the same column retention
         time

2.   Analysis of samples of unknown origin
     a.   Use of an ion-exchange resin column to remove chloro-
          phenoxyphenols
     b.   Determination of the dioxins by gas chromatography and
          mass spectrometry using multiple-ion detection

     Detection limits:
         0.05 mg/kg for TCDD

     Possible interferences:
         Presence of other compounds with the same column retention
         time

3. Analysis for TCDD contained in 2,4,5-T
   a. Use of gas chromatography
   b. Identification by mass fragmentography

   Detection limits:
       50 to µg/kg
       Recovery 80 to 100 percent

   Possible interferences:
       Presence of other compounds with the same column retention
       time

4. Dioxins from photochemical and thermochemical decomposition
   of chlorophenoxyphenols
   a. Use of gas chromatography
   b. Detection with flame ionization and mass spectometry

   Possible interferences:
       Presence of other compounds with the same column retention
       time

Permissible Exposure Limits/Threshold Limit Values

   Under study by OSHA

Materials Damage

   Chemical reactivity low, probability of materials damage low

Toxicity

   Acute toxicity:
       In animal tests, TCDD has been demonstrated to be the most
       acutely toxic compound made

   Chronic toxicity:

       Carcinogenicity--TCDD caused cancer in oral and dermal studies
       in animals. When the chemical was administered by gavage,
       exposure caused thyroid tumors in male rats and liver tumors
       in female rats. TCDD painted on the skin of mice was carcino-
       genic for female mice

       Mutagenicity--TCDD produced mutagenic effects in some short-
       term microbial bioassays

Teratogenicity--TCDD is embryotoxic and teratogenic in mice and rats. No human data are available. Positive results in these studies demonstrate that the chemical is carcinogenic for animals and that exposure is a potential hazard to humans

Other chronic toxicity:
Chloracne
Neurological effects
Liver toxicity
Anemia and other blood disorders
Kidney dysfunction
Impairment of the immune system

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Systems Applications, Inc. 1980. Human Exposure to Atmospheric Concentrations of Selected Chemicals, Vol. II. PB81-193260. Systems Applications, Inc., San Raphael, California.

U.S. Environmental Protection Agency. 1981. Dioxins. Toxic Information Series. OPTS, Washington, D.C.

Chemical Name

Epichlorohydrin

CAS Number

106-89-8

Chemical Classification

Epoxide fibrous silicate

Synonyms

2-(chloromethyl) oxirane; 3-chloro-1,2-propylene; 3-cholro-1-oxacyclobutane; gamma-chloropropylene oxide; alpha-epichlorohydrin; 1,2-epoxy-3-chloropropane; chloropropylene oxide; glycerol epichlorohydrin; glycerol epichlorhydrin; 3-chlorooxetane; 3-chloro-1,2-exoxypropane; (chloromethyl) ethylene oxide; 3-chloro-1,2-propylene oxide; 1-chloro-2,3-epoxy propane; epichlorohydrine; oxirane (chloromethyl); 2,3-epoxypropyl chloride; glycidyl chloride

Physical/Chemical Properties

Description:
Colorless liquid

Boiling point:
117.9° C

Melting point:
-25.6° C

Molecular weight:
92.53

Chemical formula:
C_3H_5ClO

Vapor pressure:
16.8mm at 2.5° C

Vapor density:
3.29

Physical/Chemical Properties

Refractive Index:
N_D^{25} 1.4359

Solubility:
5.48 percent soluble in water; soluble in most organic solvents

Photochemical reactivity:
Potential for air pollution is high; however, no data are available on photochemical reactivity

Chemical reactivity:
By suitable adjustment of reaction conditions, epichlorohydrin can be an intermediate in the synthesis of a wide variety of products

Epichlorohydrin emits highly toxic fumes when heated to decomposition

The reactivity of the compound is characterized by the terminal chlorine atom and the epoxy group

Environmental Fate

Indications of accumulative effects; however, biodegradation may occur

Sources of Emissions

Production:
Approximately 312 million lb of epichlorohydrin were produced in 1978. The total production emissions including process, storage and fugitive was estimated as 146,600 lb/yr in 1978

lb lost/lb produced

Process	0.00042-from state files
Storage	0.00001-from state files
Fugitive	0.00004-engineering estimate

Plants and locations:
Dow Chemical   Freeport, TX
Shell   Deer Park, TX
                      Norco, LA

Uses/storage/fugitive:
The ordinary end uses of epichlorohydrin are for the manufacture of epoxy resins (53%) and synthetic glycerin (25%). Other uses include the production of epichlorohydrin elastomers, glycidol ethers, surfactants, etc. End use consumption is presented in Table D-60. Epichlorohydrin emissions from epoxy resin production including process, storage and fugitive emissions total an estimated 250,800 lb/yr (1978 data). Table D-61 presents plant locations and emissions. Table D-62 presents nationwide emission losses of allyl chloride (consumed in epichlorohydrin production) and epichlorohydrin

Disposition:
The largest quantities of epichlorohydrin containing wastes originate in the production of epoxy and phenolic resins. It is expedient to destroy concentrated wastes in special incinerators to avoid the formation and emission of toxic fumes. No data are available on emissions from disposition

Sampling and Analytical Mehtods

NIOSH Method Number S 118: Epichlorohydrin

Sampling method:
A known volume of air is drawn through a charcoal tube to trap the organic vapors present

Analytical method:
The analyte is desorbed with carbon disulfide, and the desorbed sample is injected into a gas chromatograph

Detection limits:
A sample size of 210 l yielding a 1 mg sample has a working range of 2-60 mg/m^3

Possible interferences:
1. High humidity
2. Compounds with the same column retention times

TABLE D-60.　1978 EPICHLOROHYDRIN CONSUMPTION BY END-USE

End-Use	Percent of Total Consumption	End-Use Consumption (M lb)
Glycerin	25	78
Unmodified epoxy resins	53	165
Miscellaneous products	15	47
Epichlorohydrin elastomers	2	6
Export	5	16
Total	100.0	312

Source:　Systems Applications, Inc. 1980

Materials Damage

Epichlorohydrin can pit steel and attack rubber and leather. Containers used for storage and transport require special precautions

Permissible Exposure Limits

OSHA standard
    5 ppm as an 8 hr TWA
NIOSH recommendation
    0.5 ppm TWA 10 hr/40 hr week
Ceiling
    5 ppm 15 min

Human Toxicity

Chronic toxicity:

Carcinogenicity--The evidence for carcinogenicity to humans is inadequate. One epidemiological study in workers showed an excess of respiratory cancer. The evidence of carcinogenicity in animals is sufficient

Mutagenicity--The evidence in humans is insufficient; the evidence in short term tests is sufficient

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U.S. Environmental Protection Agency. 1977. Chemicals in Commerce Information System. Office of Toxic Substances. Washington, DC.

Chemical Name

Methyl chloroform

CAS Number

71-55-6

Chemical Classification

Chlorinated aliphatic hydrocarbon

Synonyms

1,1,1-Trichloroethane; alpha-Trichloroethane; chloroethene; methyl trichloromethane

Physical/Chemical Proterties

Description:
Colorless mobile volatile liquid, chloroform-like odor

Boiling point:
74° C

Melting point:
-32.6° C

Molecular weight:
133.41

Chemical formula:
CH_3CCl_3

Vapor pressure:
100 mm Hg 20° C
127 mm Hg 25° C

Solubility:
0.44 g/100 g water at 25° C, soluble in ethyl ether and ethyl alcohol

Refractive index:
1.44 at 20° C

Vapor density:
4.6 (air = 1)

Chemical reactivity:
. Liquid methyl chloroform will attack some forms of plastics, rubber and coatings. Contact with strong caustics, strong oxidizers and chemically active metals may cause fires and explosions

Sources of Emissions

Production/processing:
630 million lb were estimated as produced in 1976. The release rate from production has been estimated as 284.5 million lb/year

Uses:
Methyl chloroform has been a preferred solvent for cleaning electrical machines, electronic devices and precision instruments. It is also used as a dry cleaning agent, aerosol propellant additive, a constituent of rubber adhesives and as an additive to metal cutting oils. The environmental level of emissions for these industrial uses have been reported as <1 to 400 ppm (Data from Health Hazard Evaluation Reports, NIOSH)

Transport:
Methyl chloroform is shipped in 5 and 55 gal steel drums, tank cars, and tank trucks. Loading and unloading operations would be possible sources of high emission concentrations

Sampling and Analytical Methods

NIOSH Method number S328

Sampling method:
A known volume of air is drawn through a charcoal tube to trap the methyl chloroform present

Analytical method:
The desorbed sample is analyzed by gas chromatography

Detection limits:
Using a sample size of 3 1 the detection sensitivity
ranges from 190 to 5700 mg/m^3

Possible interferences:
1. High humidity
2. Compounds with the same retention times will interfere
with results

Permissible Exposure Limits

The OSHA standard is 350 ppm (1900 mg/m^3)

Human Toxicity

Acute toxicity:
A number of fatalities have been reported due to deliberate or
accidental exposures

Chronic toxicity:

Carcinogenicity--The available data does not permit an evalua-
tion of the carcinogenicity of methyl chloroform in humans.
A long term animal bioassay is being completed by the National
Toxicology Program in FY83

Mutagenicity--Methyl chloroform has been reported as mutagenic
in Salmonella typhimurium. Additional testing is to be
completed in FY83 by the National Toxicology Program

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Chemical Name

Nickel

CAS Number

7440-02-0

Chemical Classification

Metal

Synonyms

Carbonyl nickel powder, nickel catalyst, nickel sponge, raney alloy, raney nickel

Physical/Chemical Proterties

Description:
Silvery gray metallic, odorless powder

Boiling point:
2732° C

Melting point:
1453° C

Atomic weight:
58.7

Chemical formula:
Ni

Vapor pressure:
Essentially zero at 20° C

Solubility:
Insoluble in water

Density (specific gravity):
8.9

Chemical reactivity:
Nickel is a divalent metal with characteristic divalent metal chemistry, although it does not readily form chloro- or sulfate complexes under environmental conditions

Environmental Fate

Atmospheric reactivity--nickel carbonyl decomposes readily to form nickel oxide in dry air and/or nickel carbonate in moist air. These products are more likely to be atmospheric pollutants than is nickel carbonyl

Nickel subsulfide occurs in air in particulate form and is subject to settling, impaction, rainout and washout. It is not believed to be a significant atmospheric or water pollutant

The form of nickel in air and its possible reactions have not been extensively studied. Due to the industrial importance of nickel carbonyl, the possibility of nickel entering the atmosphere as nickel carbonyl does exist. Although nickel carbonyl is recognized as a hazard in industrial hygiene, there is a scarcity of information regarding the amount of nickel carbonyl that escapes to the atmosphere. In the atmosphere nickel is unreactive toward OH and O_3

Table D-63 presents average nickel concentrations at 30 urban National Air Surveillance Network Stations from 1957-1968

Sources of Emissions

Production:
U.S. nickel mining operations produce about 30 million lb of Nickel annually and imports are approximately 330 million lb

In 1977 there were two major nickel producers in the U.S.; the Hanna Mining Co., Riddle, Oregon, and AMAX, Inc., at Port Nickel, Louisiana. Production emissions are estimated at 500,000 lb/year

Uses:
The principal use of nickel is as an alloying agent. Nickel emissions from melting and alloying are in the form of nickel oxide or complex oxides. Other than direct use sources nickel may be released from coal and oil fired boilers, coke ovens,

275

diesel fuel burning and gray iron foundries. Emission sources have been estimated as follows:

Source	Pounds/Year
Iron and steel industry	231,000
Ferro alloy manufacturing	828,000
Gray iron foundries	186,000
Nonferrous alloy manufacturing	143,000
Electric utility power plants	8,456,000
Coke ovens	123,000
Diesel fuel use	1,785,000
Industrial boilers	6,518,000
Heating boilers	3,863,000
TOTAL	22,133,000

(OAQPS 1980)

Disposition:
Nickel scrap is a significant source of the nickel supply. Essentially all nickel scrap is returned to mills, smelters, refineries and foundries. Nickel alloy scrap is usually exported to Japan or Germany for recycling

Sampling and Analytical Methods

NIOSH Method number S 206

Sampling method:
A known volume of air is drawn through a cellulose membrane filter to collect the analyte

Analytical method:
The sample solution is aspirated into the oxidizing air-acetylene flame of an atomic absorption spectrophotometer

Detection limits:
At 26.5° C 745 mm Hg the working range of an 85 l sample is estimated to be 0.4 to 8 mg/m^3

Interferences:
There are no known interferences for the nickel atomic absorption spectrophotometer assay

Permissible Exposure Limit

OSHA standard:
1 mg/m^3 8 hour TWA (as nickel metal and soluble nickel compounds)

NIOSH recommended standard:
0.015 mg/m^3 10 hr TWA

Human Toxicity

Chronic toxicity:

Carcinogenicity--Workers in nickel refineries have increased incidences of nasal, lung, and larynx cancer. It is not possible to state with certainty which specific nickel compounds are carcinogenic to humans

Other chronic toxicity:
Pharmacokinetics, metabolism and nutritional studies for nickel are on test in FY83 sponsored by the Division of Research Resources, NIH

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U.S. Environmental Protection Agency. 1980. OAQPS Draft Exposure Assessment.

Chemical Name

Nitrobenzene

CAS Number

98-95-3

Chemical Classification

Nitroaromatic compound

Synonyms

Nitrobenzol, oil of mirbane, mononitrobenzene

Physical/Chemical Properties

Description:
Yellow oily liquid, yellow crystals in solid state

Boiling point:
210.8° C at 760 mm

Melting point:
5.7° C

Molecular weight:
123.11

Molecular formula
$C_6H_5NO_2$

Vapor pressure:
0.340 mm at 25° C

Density:
1.2037 at 20° C (water at 4° C)

Refractive index:
1.5529 - highly refractive

Solubility:
Slightly soluble in water

Octanol/water log partition coefficient:
1.88

Photochemical reactivity:
    Undergoes photoreduction when irradiated with UV

Chemical reactivity:
    Undergoes nitration, halogenation and sulfonation and is a
    strong oxidizing agent. These reactions are not likely to
    occur under environmental conditions

Sources of Emissions

Production/processing:
    In 1978 there were 5 companies producing nitrobenzene
    at 7 locations

An estimated 850 million lb were produced in 1978

The following producers and processors of nitrobenzene have
been reported:

Company	Location
American Cyanimid	Bound Brook, NJ
	Willow Island, WV
Du Pont	Beaumont, TX
	Deepwater, NJ
	Gibbstown, NJ
First Chemicals	Pascagoula, MS
Mobay Corporation	New Martinsville, WV
Rubicon	Geismar, LA
BASF Wyandotte	Wyandotte, MI
Dow	Midland, MI
Hercules	Brunswick, GA
	Harbor Beach, MI
	Hopewell, VA
	Parlin, NJ
H. Kohnstaum	Camden, NJ
	Clearing, IL
MAK Chemical	Muncie, IN

Company	Location
Procter and Gamble	Memphis, TN
Union Carbide	Institute, WV
Eastman Kodak	Rochester, NY
Monsanto	Luling, LA
Toms River Chemicals	Toms River, NJ

Production and process emissions:
263,500 lb (1978)

Uses:
The total number of estimated sites where nitrobenzene is used is 279

Most of (98%) nitrobenzene is used captively to produce aniline (1978 estimate)

Nitrobenzene is used as a solvent in the petroleum industry and in cellulose ether manufacture

Nitrobenzene is used as a chemical intermediate

Emissions from use:

Use	Emissions
Solvent applications	12.75 million lb
Production and analine manufacture	275,000 lb
Chemical Intermediate	6,000 lb

Total nationwide emissions of nitrobenzene in 1978:

13 million lb

Emissions from storage:
Storage emissions represent total losses from surge, final product, feed storage tanks, and loading and handling. Emissions range from 300-18,000 lb per year (from site visit data)

Disposition:
   Atmospheric concentrations of nitrobenzene adjacent
   to production or processing sites are believed low.
   Atmospheric nitrobenzene is not monitored by industry.
   High concentrations of wastes should be incinerated.
   Caution: poisonous nitrous gases can be produced

Sampling and Analytical Methods

NIOSH Method number S 217

Sampling method:
   A known volume of air is drawn through a silica gel
   tube

Analytical method:
   An aliquot of the desorbed sample is analyzed by GC

Detection limits:
   Method validation in range of 3.11-12.45 mg/m^3
   (23° C 765 mm) using 55 l of sample

Possible interferences:
   Vapors may not be trapped efficiently during
   periods of high humidity

   Compounds with the same column retention time
   as nitrobenzene can interfere with the analysis

Permissible Exposure Limit

OSHA Standard
1 ppm (5 mg/m^3)

Human Toxicity

Acute toxicity:
   A few ml of nitrobenzene liquid can be lethal
   to humans

Chronic toxicity:

Carcinogenicity--On test in FY83 for long term carcinogenesis animal bioassay (National Toxicology Program)

Mutagenicity--On test in FY83 for mutagenesis/genetic toxicity testing (National Toxicology Program)

Other chronic toxicity:
On test in FY 1983 for pharmacokinetics/metabolism studies (University of California)

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U.S. Department of Health and Human Services. 1978. Occupational Health Guideline for Nitrobenzene. DHHS/PHS/NIOSH, pp. 1-5.

Chemical Name

Nitrosomorpholine

CAS Number

59-89-2

Chemical Classification

N-nitroso compound

Synonyms

morpholine, 4-nitroso-, N-nitrosomorpholine, 4-nitrosomorpholine, NMOR

Physical/Chemical Proterties

Description:
Yellow crystals

Boiling point:
225° C 747 mm

Melting point:
29° C

Molecular weight:
116.1

Chemical formula:
$C_4H_8N_2O_2$

Solubility:
Soluble in water, and soluble in organic solvents

Photochemical reactivity:
Photochemically reactive, light sensitive, especially to UV

Chemical reactivity:
Resistant to hydrolysis. Strong oxidants oxidize NMOR to the corresponding nitramine

Sources of Emissions

Production/processing:
NMOR is not produced commercially and there are no reports of past commercial production

Uses:
No reported uses. NMOR has been detected as a contaminant in analytical grade dichloromethane and chloroform, in morpholine and in a rubber accelerator. Rubber or tire manufacturing workers may be exposured in the range of 9-130 ug/day

Sampling and Analytical Methods

Sampling methods:
Samples should be stored in opaque containers because of the light sensitivity of NMOR

Analytical methods:
Gas chromatography recommended for analysis of NMOR using either an electron-capture detector or alkali flame ionization detector. Confirmation should be made with a mass spectrometer or thin layer chromatography

Possible interferences:
Any compound which has the same retention time as the analyte is a potential interference. Compounds containing phosphorous or nitrogen could be sources of interference

Human Toxicity

Chronic toxicity:
There are no case reports or epidemiologic studies available

Carcinogenicity--There is sufficient evidence for the carcinogenic effect of NMOR in experimental animals and the chemical should be regarded as carcinogenic to humans

Mutagenicity--There is evidence of the mutagenic effect of NMOR in experimental animals. NMOR has been selected for further mutagenesis/genetic toxicity testing by the National Toxicology Program

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U.S. Department of Health and Human Services. 1982. Third Annual Report on Carcinogens. National Toxicology Program. DHHS/PHS. p. 231-232.

Chemical Name

Polychlorinated biphenyls, a generic term for 209 possible isomers of chlorinated biphenyls

CAS Numbers

13-36-36-3, generic
11097-69-1, Aroclor 1265
11096-82-5, Aroclor 1260

Chemical Classification

Halogenated aromatic hydrocarbon

Synonyms

PCB, chlorinated biphenyl, chlorinated diphenyl, chlorinated diphenylene, chloro biphenyl, polychlorinated polyphenyls

Trade Names

Akarel, Aroclor, Clophen, Chlorextol, Dykanol, Interteen, Kanechlor, Noflanol, Phenochlor, Pyralene, Pyranol, Sovol, Therminol

Physical/Chemical Properties

Description:
Variable appearance. Lower chlorinated Aroclors are colorless mobile oils. Increased chlorinated of the biphenyl results in increasing yellow colorations and compound viscosity

Boiling point:
Aroclor 1254, 365° C
Aroclor 1260, 390° C

The boiling points for the PCBs increase with increased chlorination

Melting point:
    2-chlorobiphenyl, 54° C
    decachlorobiphenyl, 310° C

    Melting points for the PCBs increase with the chlorination of
    the biphenyl. The PCBs do not crystallize upon heating or
    cooling, but at specific temperatures defined as pour points,
    they form resinous compounds

Molecular weight:
    Exact molecular weights of the PCBs are unknown

Chemical formula:
    The PCBs most frequently occur as mixtures; exact chemical
    formulas are unknown

    General formula: $C_{12}Cl_xH_x$ (x = 1 to 10)

Log partition coefficient (octanol/H_2O):
    10,000 to 20,000 for representative tri-, tetra-, and penta-
    chlorobiphenyls

Refractive index:
    Aroclors, 1.617-1.640 at 20° C
    Kaneclors, 1.623-1.690 at 25° C

Solubility:
    The PCBs are generally considered insoluble in water

    Aroclor 1254, 0.1 µg/l

    Chlorobiphenyls are freely soluble in nonpolar organic
    solvents and lipids

Density:
    1.495 to 1.505

Vapor pressure:
    1 mm at 25° C

Photochemical reactivity:
    Transformation products--
        Reactivity toward OH: 5% butane
        Reactivity toward O_3: no reaction
        Photolysis: free radicals can form that may result in
        the formation of the contaminant chlorodibenzofurans

Chemical reactivity:
    PCBs are considered inert to most of the typical chemical
    reactions. These compounds do not undergo oxidation, reduc-
    tion, addition, or elimination except under extreme conditions

Environmental fate

Due to their chemical stability, environmental persistence, and
tendency to bioaccumulate, the PCBs have continued to present
an environmental hazard despite regulatory actions

Air:
    Vaporized PCBs can be adsorbed onto particulates and trans-
    ported with the prevailing wind. Ultimately they will be
    deposited on land or water

Water:
    PCBs found in water are mainly adsorbed to particulate matter
    and sediment. Because of their low aqueous solubility, PCBs
    discharged into water bodies will accumulate and redissolve
    very slowly. Fish can bioaccumulate 10^5 times more PCBs
    than are found in surrounding waters

Soil:
    The primary source for PCBs in soil is atmospheric fallout
    Estimated half-life in soil: 5 years
    Estimated residence time: 35 years
    Large fractions of PCBs in soil may leach into adjacent water
    bodies

Sources of Emissions

Production:
    Except for limited research and development applications, the
    PCBs are no longer produced domestically, and no importation
    or exportation of the compounds has been permitted since July
    1979. United States production peaked in 1970 when greater
    than 80 million pounds was manufactured principally in Illinois

Uses:
  PCBs are no longer used or consumed for any kind of end use in
  the United States, and end use is no longer a source of PCB
  emissions

  Prior common uses have been in transformer and capacitor
  fluids, electrical insulations, plasticizers, hydraulic
  fluids, epoxy paints, carbonless reproduction papers, and
  certain lubricants. These prior uses have continued to be
  sources for environmental and human exposure

Storage:
  The loss of PCBs by evaporation or leakage when stored in
  closed systems such as in transformers and capacitors is not
  believed to be a significant emissions source

  EPA regulations specify the types of containers that can be
  used for the storage of liquid containing PCBs prior to
  incineration

Transportation:
  Not significant

Disposition:
  The only significant sources of PCB emissions to the atmo-
  sphere are from the disposal of PCB-containing transformers
  and capacitors. When PCBs and PCB-containing products are
  disposed of, disposal must be undertaken in accordance with
  EPA regulations. In 1980 there were the following existing
  and proposed incineration sites:

*Bridgeport, NJ	Chicago, IL
*Deer Park, TX	Sandusky, OH
*Baton Rouge, LA	Atlanta, GA
San Francisco, CA	Richmond, VA
Los Angeles, Ca	Waterford, NY
Denver, CO	El Dorado, AR

  * Designates incinerator site existing in 1980

  Annual emissions of PCBs if all 12 sites are operational is
  estimated to be between 3,000 and 30,000 lb/yr

  The concentration of PCBs in PCB-containing wastes determines
  the disposition. Wastes that contain PCBs greater than
  500 ppm require incineration. Chemical landfill disposal is
  permitted for specified wastes provided all free-flowing PCBs
  have been drained for incineration

Sampling and Analytical Methods

1. Polychlorinated Biphenyls in Air--Method Number P&CAM 244
   a. Adsorption of Florisil
   b. Hexane desorption
   c. Gas chromatography with electron capture detection

   Detection limits:
   The estimated range of detection for this method is 0.01 to 10 mg/m^3. The minimum detectable quantity of PCB from a standard curve was determined as 32 pg per injection. Field samples analyzed by this method ranged from 0.1 to 1.5 mg/m^3

   Possible interferences:
   Compounds with nearly the same retention time as the PCB sample on the GC column. The chlorinated pesticides such as DDT, DDE, etc., have been reported to interfere with determinations, and sulfur-containing compounds in petroleum products have been reported as interferences

2. Polychlorinated Biphenyls in Air--Method Number P&CAM 253
   a. Adsorption in Florisil
   b. Hexane desorption
   c. Perchlorination
   d. Gas chromatography with electron capture detection

   Detection limits:
   The estimated useful range of this method is 0.01 to 10 mg/m^3. The minimum detectable limit of decachlorobiphenyl, the perchlorination product, is 10 pg per injection

   Possible interferences:
   Compounds with the same column retention time or nearly same. Chlorinated pesticides, sulfur-containing compounds in petroleum products, and biphenyl, if present in the PCB mixture

Permissible Exposure Limits/Threshold Limit Values

PEL: 1 mg/m^3, 8-hour Time Weighted Average (42 percent chlorine)
0.5 mg/m^3, 8-hour Time Weighted Average (54 percent chlorine)

TLV: 1 mg/m^3, 8-hour Time Weighted Average (42 percent chlorine)
0.5 mg/m^3, 8-hour Time Weighted Average (54 percent chlorine)

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Chemical Name

Toluene

CAS Number

108-88-3

Chemical Classification

Aromatic hydrocarbon, alkylbenzene

Synonyms

Methacide, methylbenzene, methylbenzol, phenylmethane, toluol

Physical/Chemical Properties

Description:
Colorless, volatile, flammable liquid at ambient temperatures; very refractive; noncorrosive; sweet odor, similar to benzene, but milder

Boiling point:
110.6° C

Melting point:
-95.0° C

Molecular weight:
92.15

Chemical formula:
C_7H_8

Vapor pressure:
24 mm Hg at 25° C; 22 mm Hg at 20° C; 36.7 mm Hg at 30° C

Log partition coefficient (Octanol/H_2O):
2.80

Refractive index:
N_D: 1.49693 at 30° F
1.49414 at 77° F

Solubility:
    Slightly soluble (4.7 g/l H_2O); sol. in alcohol and
    ether

Density:
    0.86694 g/ml at 20° C
    0.86230 g/ml at 25° C

Vapor density:
    3.1 (air = 1)

Photochemical reactivity:
    Effective ambient air decay rate: 2.8 x 10^{-5} s^{-1} (daytime)
    Reactivity toward: OH is 2X butane
    No reactivity toward O_3 or photolysis

Chemical reactivity:
    Reacts with oxidizing materials

Environmental fate

    Can persist in atmosphere. Its high volatility and low sol-
    ubility in water enables it to volatilize from water surfaces
    to the atmosphere

Sources of Emissions

    Production:
        An estimated 67,000 million lb of toluene was produced
        in 1978

        Several petroleum or petrochemical processes:
        a. from catalytic reformate from refineries (principal
            method in U.S.) an estimated 64,875 million lb was
            produced in 1978
        b. hydrocracking
        c. steam cracking
        d. catalytic cracking

By-product sources:
a. from coal carbonization, an estimated 175 million lb
    of toluene was produced in 1978
b. as BTX (Benzene, Toluene, Xylene) from petroleum-
    derived pyrolysis gasoline, an estimated 1,560
    million lb was produced in 1978 from this source
c. from olefin manufacturing during cracking of hydro-
    carbons
d. from styrene manufacturing, 320 million lb of toluene
    was produced in 1978
e. from coal-derived BTX, 175 million lb of toluene was
    produced in 1978

Uses:
Toluene isolated from BTX:

a. Chemical intermediate:
    benzene manufacturing (by dealkylation)
    toluene diisocyanate products
    xylenes (via disproportionation)
    benzoic acid manufacturing
    benzl chloride
    vinyl toluene
    benzaldehyde
    p-cresol
    backblending into gasoline
b. solvent
    paints
    rubber
    plastics
    coatings
    pharmaceuticals
c. in manufacturing of artificial leather, photogravure
    inks

All toluene produced as BTX and not isolated is blended into
gasoline

Tables D-64 through D-67 and Figure D-5 present toluene produc-
tion, consumption, and emission data

TABLE D-64. 1978 TOLUENE PRODUCTION AND CONSUMPTION

Source	Isolated Toluene (M lb)	Toluene in BTX (M lb)	Total Toluene Produced (M lb)
Production			
Catalytic reformate	8,000	56,875	64,875
Pyrolysis gasoline	830	730	1,560
Coal derived	145	30	175
Styrene by-product	220	100	320
Total	9,195	57,735	66,930

Source: Systems Applications, Inc. 1980

TABLE D-65. END-USE CONSUMPTION

End Use	Isolated Toluene Used (%)
	35
Gasoline as BTX	
Gasoline isolated (back blended)	
Benzene dealkylation	
Paints and coating solvent	
Adhesives, inks, pharmaceuticals solve	
Toluene diisocyanate	
Xylenes (disproportionation)	
Benzoic acid	
Benzyl chloride	
Vinyl toluene	
Benzaldehyde	
p-Cresol	
Miscellaneous others	
Net export	
Total	

Source: Systems Applications,

TABLE D-64. 1978 TOLUENE PRODUCTION AND CONSUMPTION

Source	Isolated Toluene (M lb)	Toluene in BTX (M lb)	Total Toluene Produced (M lb)
Production			
Catalytic reformate	8,000	56,875	64,875
Pyrolysis gasoline	830	730	1,560
Coal derived	145	30	175
Styrene by-product	220	100	320
Total	9,195	57,735	66,930

Source: Systems Applications, Inc. 1980

TABLE D-65. END-USE CONSUMPTION

End Use	Isolated Toluene Used (%)	Toluene Used (M lb/yr)
Gasoline as BTX		57,735
Gasoline isolated (back blended)	35.1	3,230
Benzene dealkylation	40.2	3,693
Paints and coating solvent	6.3	579
Adhesives, inks, pharmaceuticals solvent	3.2	291
Toluene diisocyanate	4.8	440
Xylenes (disproportionation)	2.3	216
Benzoic acid	1.6	144
Benzyl chloride	0.8	79
Vinyl toluene	0.6	55
Benzaldehyde	0.2	18
p-Cresol	0.1	14
Miscellaneous others	0.6	53
Net export	4.2	383
Total	100.0	66,930

Source: Systems Applications, Inc. 1980

TABLE D-66. TOTAL NATIONWIDE 1978 TOLUENE EMISSIONS

Source	Toluene Emissions (lb/yr)
Toluene production - catalytic reformate	6,487,500
Toluene production - pyrolysis gasoline	1,404,000
Toluene production - coal-derived	218,750
Toluene production - styrene by-product	243,200
Paint and coatings solvent	579,000,000
Adhesives, inks, pharmaceutical solvent	247,000,000
Benzene production	738,600
Toluene diisocyanate production	563,200
Benzoic acid production	216,000
Benzyl chloride production	79,000
Vinyl toluene production	55,000
Benzaldehyde production	27,000
p-Cresol production	28,000
Xylene disproportionation production	43,200
Other/miscellaneous uses	20,140
Gasoline - marketing evaporative loss	38,492,000
Gasoline - automobile evaporative loss	35,400,000
Gasoline - automobile exhaust emissions	1,300,147,000
Coke ovens	25,680,000
Total	2,235,842,590

Source: Systems Applications, Inc. 1980

Storage:
   Outside/detached storage or inside in standard flammable
   liquids storage room/cabinet. Separate from oxidizing
   materials

Transportation:
   In glass bottles, cans, drums, tank cars, tank trucks, or
   tank barges

Disposition:
   Toluene wastes originate mainly in petrochemical plants
   as well as plants which use toluene as a raw material for
   synthesis of the above-mentioned compounds. Further sources
   of waste are installations which blend fuels and plants which
   utilize toluene as a solvent

   When discharging wastes of low toluene content into the
   sewer system, the local discharge regulations have to be
   observed. Solvent wastes from which toluene cannot be recovered
   and toluene-containing sludges are burnt. Distillation residues
   and toluene-containing sludges are disposed of in special
   waste incinerators

Sampling and Analytical Methods

1. EPA "Preferred Method"
    a. Tenax GC sorbent collection (gives pre-
        concentrated samples)
    b. Thermal elution
    c. Gas chromatographic/flame ionization detector
        determination

    Detection limits: (depend on sample volume)
        0.1 ppb with capillary column and
        flame ionization detector--25 1 sample on sorbent trap

        0.3 ppb with gas chromatographic/photoionization detector
        directly injected--1 ml sample

    Possible interferences:
        High humidity
        Interfering compounds possibly also present in the air
        Any compound with the same column retention time

302

2. NIOSH Method S 343 for Toluene
   a. Adsorption on charcoal
   b. Desorption with carbon disulfide
   c. Gas chromatographic analyses

   Detection Limits:
       0.01 mg/0.5 1 for a 22 1 sample at 16x1 attenuation on a
       gas chromatograph fitted with a 10:1 splitter

   Possible interferences:
       High humidity
       Other solvents in air
       Presence of other compounds with same retention time

3. See Appendix A
   Cryogenic trapping or Tenax adsorption appear to be
   the best approaches. GC/PID is a useful determinative
   technique

Materials Damage

Toluene will attack some forms of plastics, rubber, and coatings.
Containers may burst at elevated temperatures

Permissible Exposure Limits/Threshold Limit Values

	OSHA	NIOSH	ACGIH
TWA	200 ppm	100 ppm	100 ppm (375 mg/m^3)
Ceiling	300 ppm	200 ppm/10 min	150 ppm (560 mg/m^3)
Peak	500 ppm/10 min		

Odor perception: TLV 40 ppm

Human Toxicity

Acute toxicity:
    Inhalation: 200 ppm TC_{LO} - central nervous system
                100 ppm TC_{LO} - psychotrophic

Chronic toxicity:

Carcinogenicity--On test for carcinogenicity in FY83 (U.S.
DHHS 1983)

Mutagenicity--On test for mutagenesis/genetic toxicity in FY83
(U.S. DHHS 1983)

Teratogenicity--Tests to be completed in FY83 for reproductive/
developmental toxicity (U.S. DHHS 1983)

Other chronic toxicity:
   Blood abnormalities
   Bone marrow chromosome damage
   Metabolic effects
   Enzymatic effects
   Increased liver microsomal enzymes
   Neurological/behavioral toxicity testing to be completed
      in FY83 (U.S. DHHS 1983)
   Pharmacokinetics/metabolism testing to be started in FY83
      (U.S. DHHS 1983)

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Chemical Name

Trichloroethylene

CAS Number

79-01-6

Chemical Classification

Chlorinated Hydrocarbon

Synonyms

Acetylene trichloride; 1-chloro-2,2-dichloroethylene; 1,1-dichloro-2-chloroethylene; ethinyl trichloride; ethylene trichloride; TCE; Tri; trichlorethylene; 1,1,2-trichloroethylene

Physical/Chemical Proterties

Description:
Colorless liquid, volatile, nonflammable

Boiling point:
87° C

Melting point:
-73° C

Molecular weight:
131.4

Chemical formula:
C_2HCl_3

Vapor pressure:
77 mm Hg at 25° C

Solubility:
Miscible with H_2O (0.1% w/v at 20° C); miscible with acetone, ethanol, diethyl ether, chloroform and oils.

Log Partition Coefficient (Octanol/H_2O):
2.29

Photochemical reactivity:
High photochemical reactivity; oxidative breakdown of atmospheric oxygen, greatly accelerated by elevation of temperature and exposure to light, especially UV

Chemical reactivity:
Slowly oxidized by O_3 and RO_2, products are phosgene, HCl, CO, trichloroethylene oxide and dichloroacetylchloride; unreactive toward OH

Density:
1.4642 at 20° C (4° C water)

Environmental Fate

Not expected to accumulate in atmosphere due to low solubility and reactivity. Half-life in air range from 157 minutes to 8 hours, longer in water

Sources of Emissions

Production/processing:
From acetylene (high manufacturing cost)

By chlorination of ethylene

By oxychlorination of ethylene or dichloroethane (perchloroethylene is a byproduct)

Uses:
In industrial metal fabricating industry for vapor degreasing and cleaning operations

Solvent/solvent base for adhesives, sealants, lubricants, and dip-painting processes

Textiles

Low temperature heat transfer fluid

Component in spot remover and cleaning fluids for rugs, etc.

Pharmaceutical grade used as general anesthetic and an analgesic

Tables D-68 to D-72 present estimated production, end uses, and emission losses

Storage and Transport:
    Stored in cool dry places, well-ventilated, away from sunlight and heat. Shipped in 5 and 55 gal steel drums, tank cars and tank trucks, barges

Disposition:
    60% of world's annual production is released to environment with most to the atmosphere. Disposal methods include:
        Incineration
        Aqueous waste
        Waste solvent reclammation
        Waste solvent landfills

Sampling and Analytical Methods

1.	Sample Type	Extraction/Clean-Up	Detection	Limit of Detection
	Air			
	Ambient	Trap in Drechsel flask fitted with rubber septum, sample with gas syringe	GC/ECD	1 µg/m^3
	Ambient	Analyze directly	GC/ECD	10 mg/m^3
	Rural	Trap on porous polymer, desorb, by heating, retrap in line on GC column	GC/ECD; GC/MS	160 ng/m^3 (30 ppt)
	Atmosphere	Analyze directly	GC/MS	27 ng/m^3 (5 ppt)
	Ambient	Analyze directly	Carbon dioxide laser	1.8 µg/m^3 (0.7 ppb)
	Ambient	Analyze directly	Carbon dioxide laser	23 µg/m^3 (4.2 ppb)

Source: IARC 1979

2. NIOSH method S 336 for trichloroethylene
   a. Adsorption on charcoal
   b. Desorption with carbon disulfide
   c. Gas chromatographic analyses

   Detection limits:
       0.01 mg/0.5-22 1 of sample

   Possible interferences:
       High humidity (decreases breakthrough volume)
       Two or more solvents present of different polarities
       Two or more solvents present with same retention time
       as trichloroethylene

3. Methods B, C, or D from Appendix A
   Cryogenic trapping or Tenax adsorption appear to be
   the best approaches. GC/PID is a useful determinative
   technique

Materials Damage

Trichloroethylene will attack the common metals, even in the presence of moisture

Permissible Exposure Limits

	OSHA	NIOSH	ACGIH
TWA	100 ppm	100 ppm	50 ppm (150 mg/m^3)
Ceiling	200 ppm	150 ppm/15 min	150 ppm (805 mg/m^3)
Peak	300 ppm/5 min in any 2 hrs		

Human Toxicity

Acute toxicity:
    Inhalation of 160 ppm (83 minutes) = TC_{LO} for central nervous
    system effects

Chronic toxicity:

    Carcinogenesis--testing to be completed in FY83 (U.S. DHHS
    1983)

    Mutagenicity--mutagenesis/genetic toxicity testing ongoing in
    FY83 (U.S. DHHS 1983)

    Teratogenicity--selected for reproductive/developmental
    toxicity testing, date not determined

Other chronic toxicity:
        Kidney, spleen, and liver damage
        Metabolic and enzymatic effects
        Hypertension
        Decreased ATP level
        Reduces antibody formation

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Chemical Name

Vinyl chloride

CAS Number

75-01-4

Chemical Classification

Halogenated unsaturated hydrocarbon

Synonyms

Chlorethene, chlorethylene, chloroethene, chloroethylene, ethylene monochloride, monochloroethene, monochlorethylene, Trovidur, VC, VCM, vinyl chloride C monomer, vinyl chloride monomer

Physical/Chemical Properties

Description:
    Colorless gas (pure substances)

Boiling point:
    -13.37° C

Melting point:
    -153.8° C

Molecular weight:
    62.5

Chemical formula:
    C_2H_3Cl

Vapor pressure:
    2530 mm at 20° C

Refractive index:
    n_D^{20} 1.3700

Solubility:
Slightly soluble in water, 0.11/100 g at 25° C; soluble in ethanol; very soluble in ether, carbon tetrachloride, and benzene

Density:
0.9106 at 20° C (water at 4° C)

Vapor density:
2.2 (air = 1)

Photochemical reactivity:
Vinyl chloride undergoes atmospheric reactions in the presence of nitrogen oxides and solar radiation. The reaction rate is slower than other atmospheric hydrocarbons that have been studied. Reaction products of vinyl chloride photo-oxidation include carbon monoxide, formaldehyde, formic acid, formyl chloride, and hydrogen chloride. The half-life of vinyl chloride in laboratory experiments was reported as 6 hours. No data were available on the half-life of vinyl chloride in the ambient atmosphere

Chemical reactivity:
On treatment with strong alkalis at high temperatures, vinyl chloride loses hydrogen chloride. Reacts with hydrogen peroxide, oxides of nitrogen, sulfuric acid, and ozone in ambient air

Environmental fate

Vinyl chloride should disappear significantly in its transport over long distances; however, in the immediate vicinity of emission sources, it is considered a stable pollutant. Vinyl chloride is so volatile that it does not bioaccumulate or transfer appreciably through food chains. Vegetational damage around manufacturing or processing plants has not been documented. The polyvinyl chloride products made from vinyl chloride are not readily biodegradable

Sources of Emissions

Production:
The annual production of vinyl chloride in the United States is approximately 7 billion lb. The total emissions from the 10 vinyl chloride monomer production sites operated in 1975 were estimated to be 30 million lb/yr, based on an emission rate of 0.45 percent of production

Byproduct sources:
　　Polyvinyl chloride plants use an estimated 95 percent of the
　　vinyl chloride produced. Vinyl chloride emissions in 1975
　　from U.S. polyvinyl chloride polymer plants were approximately
　　240 million lb. This figure represents extrapolated figures
　　based on estimated emissions of 4 percent vinyl chloride
　　during polymer production and recovery, and full capacity
　　operation. The location of vinyl chloride and polyvinyl
　　chloride plants is presented in Figure D-7

　　Maximum 24-hour air concentrations around plants ranged from
　　0.32 to 10.6 ppm. Fabrication plants produced lower vinyl
　　chloride emissions than production plants

　　NESHAP addressed vinyl chloride emissions from vinyl chloride
　　monomer production and polymerization. The imposed engineering
　　controls have been shown to reduce emissions by 95 percent
　　over precontrol levels

Uses:
　　The principal use of vinyl chloride is in the production of
　　vinyl chloride homopolymer and copolymer plastics. The
　　remainder is used in the synthesis of several chemicals

　　Vinyl chloride was formerly used as a component of aerosol
　　propellants. This use was banned by EPA, FDA, and CPSC in
　　1975

Storage:
　　During bulk polymerization, intermittent storage losses of
　　vinyl chloride were reported as high as 20 percent. Intensive
　　maintenance is capable of reducing these sources of fugitive
　　emissions 50 to 75 percent

Transportation:
　　Monomer loading and unloading are potential sources of inter-
　　mittent vinyl chloride emissions. Special controls have been
　　suggested, such as vapor collection adapters with recycling,
　　thermal level detectors with recycling, and magnetic gauges to
　　limit loading area losses

Disposition:
   Limited data are available on the levels of vinyl chloride
   emissions from the incineration of plastics. Emissions from
   incineration are expected to vary as a function of temperatures
   and types of plastic incinerated. The following are repre-
   sentative:

Temperature (°C)	25-280	280-350	350-430	430-510
Emissions (mg/g)	0.04	0.25	0.17	0.02

Sampling and Analytical Methods

1. Method Number P&CAM 178 Matrix Air
    a. Adsorption on activated carbon
    b. Desorption with carbon disulfide
    c. Gas chromatographic detection

    Detection limits:
       The detection limit of the method was determined as
       0.008 mg/m^3 in a 5-liter air space sample. The minimum
       detectable amount of vinyl chloride was 0.2 ng per
       injection (1 x 1 attenuation on a gas chromatograph)

    Possible interferences:
       a. High humidity decreases the adsorption capacity of
           activated carbon
       b. Compounds with the same column retention time as
           vinyl chloride will interference in determinations

Materials Damage

Vinyl chloride is an extremely volatile gas, and appropriate
precautions must be taken in handling this human carcinogen

Permissible Exposure Limits/Threshold Limit Values

OHSA
   1 ppm 8 hour Time Weighted Average
   5 ppm/15 minutes Time Weighted Average Ceiling

Toxicity

Acute toxicity:
   Vinyl chloride is of low order acute toxicity. Produces
   anesthetic effects accompanied by cardiac irregularities and
   pulmonary edema

Chronic toxicity:

> Carcinogenicity--There is sufficient evidence that vinyl chloride monomer is a human carcinogen. Its target organs are the liver, brain, lung, blood and lymphatic systems

> Mutagenicity--Vinyl chloride induces mutagenicity in short-term cellular testing. Chromosomal aberrations were induced in workers exposed to levels of 25 ppm. No chromosomal aberrations were induced when exposure to vinyl chloride was reduced to 15 ppm

> Teratogenicity--Studies indicate increased rates of birth defects among children residing in communities where vinyl chloride production and polymerization plants are located. Further investigation of its teratogenicity is needed

Other Chronic toxicity:
Low grade liver and kidney damage
Degeneration of finger bones associted with direct
 physical contact with high levels of the monomer
Hypertension following chronic exposures
Circulatory system disturbances such as fibrosis in
 arteries

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Chemical Name

Vinylidene chloride

CAS Number

75-35-4

Chemical Classification

Vinyl halide

Synonyms

1,1-Dichloroethene; 1,1-dichloroethylene; 1,1-DCE; VDC

Physical/Chemical Proterties

Description:
Highly volatile, clear liquid

Boiling point:
32° C

Melting point:
-122.1° C

Molecular weight:
97.0

Chemical formula:
$C_2 H_2 Cl_2$

Vapor pressure:
400 mm at 14.8° C

Refractive index:
n_D^{20} 1.424

Solubility:
Insoluble in water (0.4% wt/vol at 20° C)

Photochemical reactivity:
Photooxidizes rapidly

Vapor density:
3.4 (air = 1)

Chemical reactivity:
Easily polymerized at temperatures above 0° C

Environmental Fate

VDC emissions to the atmosphere are estimated to be shortlived.
The half life is in the order of several hours

Sources of Emissions

Production/Process:
Domestic production was reported as 386,000,000 lb by
Five producers in two regions (public record, TSCA Inventory)

The following companies reported production to EPA in 1977:

Producer	Location
Dow Chemical Co.	Freeport, TX
	Plaquemine, LA
PPG Industries, Inc.	Lake Charles, LA
Continental Oil Co.	West Lake, LA

VDC emission losses during production are in the range of
1.2 to 3.1 g/kg produced

Most of the VDC emissions are process losses. Estimated
annual emissions from processing are presented in Table D-73.
New control technologies since 1974 have probably reduced
the total emissions

Uses:
VDC has two main commercial uses: the production of
1,1,1-trichloroethane and the synthesis of various polymers
used in food packaging; coatings; resins, latexes; films
and extruded fibers. There are scant data available on
the migration of VDC monomer from products

Storage/transport:
Storage, transfer and filling operations have been esti-
mated to account for about 25% of the total environment
VDC emissions

Disposition:
   VDC (primarily in polymerized form) is disposed of in
   landfills. No data are available on emissions from this
   source

Sampling and Analytical Methods

NIOSH Method number P&CAM 266

Sampling:
   A known volume of air is drawn through a charcoal tube
   to trap the VDC present

Analysis:
   An aliquot of the sample desorbed with carbon disulfide
   is analyzed by gas chromatography

Detection limits:
   The lowest quantifiable limit was determined as 7 µg of
   VDC per sample

Possible interferences:
   1. Stability of sample
   2. Humidity
   3. Presence of other substances in the sample with
       the same column retention times as VDC

Threshold limit Values

U.S. TLV 10 ppm (40 mg/m^3)

Human Toxicity

Chronic Toxicity:

   Carcinogenicity--The available epidemiological studies do not
   permit an assessment of human carcinogenicity. VDC does
   produce malignant tumors in experimental animals

   Mutagenicity--VDC is mutagenic in S. typhimurium and E. coli;
   no data are available for humans

   Teratogenicity--Fetotoxicity and embryotoxicity have been
   demonstrated in animals; no adequate data for humans

Other chronic toxicity:
Additional biochemical cellular, tissue effects and
pulmonary toxicity testing is to be started in FY83
(National Heart, Lung, and Blood Institute)

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16. ABSTRACT

Procedures for selecting air monitoring sites are provided and discussed. A significant amount of information regarding 43 selected noncriteria pollutants is also presented. The document is a useful guideline for systematically setting priorities, identifying siting areas, and selecting specific sites that will meet the data needs for air monitoring responsibilities. The characteristics of each of the selected noncriteria pollutants are presented, including physical properties, sources of emissions, emission estimates, sampling and analysis methods, and toxicity. The siting procedures deal with a range of representative spatial scales varying from less than 100 m to 50 km.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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